National Park Service
U.S. Department of the Interior

Glacier National Park
Montana

Glacier's Plant Invaders

A Non-Native, Invasive Plant Educational Trunk
Grades 3 – 12 Teacher Guide and Materials

National Park Service
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Glacier National Park
Montana

Quick Start Card

To arrange a field trip to Glacier National Park, Grades 6-12, call the Education Specialist at 406-888-5837. To see information about this field trip, see The Plant Invaders Binder, #3, Invasive Weed Investigations or look online: http://www.nps.gov/glac/forteachers/classrooms/plant-invaders-citizen-science- field-trip.htm.

Here is a quick guide to get you started with this trunk. Below are short activities and lessons to begin!

- **Grades 3-5**
  1. In Glacier's Plant Invaders: The Plant Invaders Binder, go to #1 Doing Science, Grades 3-5, Activity 1. Here you will find a lesson plan that engages students in understanding the definition of an ecosystem. ***You will need a carton of milk but everything else is provided in the box.***
  2. In Glacier's Plant Invaders: The Plant Invaders Binder, go to #2 Invasive Weeds "101" Grades 3-5, Activity 1. Show the Invaders Uncovered PowerPoint found on the ***CD inside the binder jacket. Narrative is in Binder.***

- **Grades 6-8**
  1. In Glacier's Plant Invaders: The Plant Invaders Binder, go to #2 Invasive Weeds "101" Grades 6-8, Activity 1. Introduce the Wheel of Logic and have students complete Activity #2, 'How Many Drops of Water on a Penny?' ***You will need to make student copies of the Wheel of Logic and worksheet, 'How Many Drops of Water on a Penny?' Students will need water in small paper cups.***

- **Grades 9-12**
  1. In Glacier's Plant Inaders: The Plant Invaders Binder, go to #2, Invasive Weeds "101" Grades 9-12. Activity #1. Introduce the lesson from the binder, A weed by Any Other Name and show students the accompanying PowerPoint either from the ***CD in educational box or online at Knoweeds Curriculum/Lesson 13.***

National Park Service
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Montana

Plant Invaders Trunk

Inventory

Borrower:_____

Booking Period:_____

The borrower is responsible for the safe use of the trunk and all its contents during the designated booking period. Replacement and/or repair for any lost items and/or damage (other than normal wear and tear) to the trunk and is contents while in the borrower's care will be charged to the borrower's school. If you have any questions please contact Laura Law at (406) 888-5837 or laura_law@ nps.gov.

Please have an adult complete the trunk inventory checklist below, both when you receive the trunk and when you repack for return.

Item	Before	After	Condition
Glass cake pan			
Dish soap			
Boxes of colored pencils (5 total)			
Yellow rope for starting line			
Pre-activity Materials Box			
Toothpicks			
Food coloring			
Noxious Weed Fact Cards (5sets)			
Invaders Uncovered CD			
How many Drops of H20			
Copies of field guide pages			
Blue Plastic Folder			
Laminated field trip lesson plan			
Laminated "Who's who" clues			
Laminated :Great Race" instructions			
Data recorded sheets (red plastic folder)			
Brown Folder "Great Race"			
Instruction sheet			
Plant cards (26 total)			
Plant Investigation Folders (5 total)			
Instruction card			
Pressed plant parts			
Hand lenses (5 total)			
Noxious Weed Fact Cards (4 per folder)	/	/	(Not included)
Noxious Weed Poster			
Supporting Materials			
Montana's Noxious Weeds Booklets (5 total)			
Crown of the Continent Booklets (5 total)			
Natural Inquirer Activity Guide			

Please complete the trunk evaluation form (on reverse) and return it with the trunk.

Thank You!

National Park Service
U.S. Department of the Interior

Glacier National Park
Montana

Plant Invaders Trunk

Evaluation Form

Name:_____

School:_____

1. How did you use the materials?
   - ☐ Large group/school-wide
   - ☐ Classroom instruction
   - ☐ Supplement to regular curriculum
   - ☐ Other

2. How would you describe the audience?
   - ☐ Preschool
   - ☐ ___Grade
   - ☐ ___High School

3. Which trunk materials were most engaging? *(Check all that apply)*
   - ☐ Lessons/curriculum
   - ☐ PowerPoint presentation
   - ☐ Field guide
   - ☐ Plant Investigation Folders
   - ☐ Other

4. How many students interacted with the trunk materials/curriculum?_____

5.How much instructional time did you use with the trunk contents?_____

6. In terms of the content/material in the trunk, what "worked" for you?

7. What did not work well for you and/or what suggestions do you have for improvement?

8. Do you have any suggestions for topics/themes for future trunks?

Invasive Plants Trunk Welcome Note

Dear Educator,

On behalf of Glacier National Park Education Staff, we thank you for checking out our Glacier's Plant InvadersTrunk. Inside you will find all kinds of exciting hands-on materials, lesson plans, and resources to help you teach your students about invasive plants.

Please use the '**Plant Invadors Trunk' Inventory** as a 'check-and-balance' that the trunk contains everything listed on the inventory sheet. You can use this same sheet as **a return inventory** sheet to make sure that everything has been placed back into the trunk for its return to us.

Included in this 3-ring binder is background information about four specific invasive plants in your area that are also found in Glacier National Park. We've included a CD with digital files of everything in this binder so that you can copy and save information for future use. Most of these activities can be done without the trunk. Feel free to copy what you need for later use. We have also included in the table of contents, links to online copies of the lessons and materials, when available.

Sharing the trunk with other classrooms is encouraged. However, you, as the person who checks out the trunk, are responsible for its contents and returning it on time. Please report missing or broken items so that replacements can be arranged.

Before you return the trunk, be sure to fill in the evaluation (on the back of the inventory sheet). We will use your feedback to improve the Plant Invaders trunk and to develop new trunks.

Thank you so much. I hope you really enjoy this educational trunk.

Sincerely,

Laura Law,
Educational Specialist
Glacier National Park

Glacier's Plant Invaders : A Non-Native, Invasive Plant Educational Trunk Overview

Grade Level: 3-12

Subjects: Life Science, Math, Communication Arts

Setting: classroom and optional field trip to Glacier National Park

Skills: Observing, Organizing, Analyzing, Drawing

Vocabulary: ecosystem, biotic, abiotic, species, organism, invasive, noxious, diversity, hypothesis, variable, adapt

Summary

Students will learn about ecosystems through explanation, simple experiments using the scientific method, games, activities, and an optional field trip.

Objectives

Students will:

- Describe how native communities are affected by noxious weeds.
- Relate how the scientific method can help park managers understand complex resource issues.
- Understand the steps of the scientific method.
- Identify five noxious weeds

Teacher Background

Preserving the natural ecosystem is the goal of Glacier National Park. Preservation means keeping the native plants strong and healthy; preventing the "outlaw" weeds from getting in; and taking action against the outlaws that have already crossed into the park. Integrated Weed Management is the approach used to control invasive weeds in Glacier. This approach targets a weed then selects the methods of treatment best suited for the location. Control of weeds within the park is undertaken cautiously to prevent damage to native plants, animals, and aquatic resources. Actions are based on research and consultation with field experts.

Noxious weeds are the "outlaws" of the plant world. They may be pretty, but they are out of place and up to no good. From a distance, weeds do not seem so bad. But take a closer look and you will see the weeds choking out the native wildflowers, grasses, and shrubs. These native plants protect the soil, attract and sustain a variety of wildlife, and add to the park's biodiversity.

The flora of Glacier includes 1050 plant species, with 126 being non-native plants. Many of these non-natives are ornamental species, although 16 are considered invasive. Some of the most troublesome invasive non-native weeds, or noxious weeds, include spotted knapweed, leafy spurge, oxeye daisy, St. Johnswort, and orange hawkweed.

The most aggressive weeds spread into grasslands and forests, reducing wildlife habitat, increasing soil erosion, and diminishing the diversity of park flora.

Many noxious weeds come from other parts of the world. They arrived in America without the insects, plant diseases, competing plants, and other natural controls that kept their populations in check within their native countries. Once established, weeds are tough to get rid of because they produce hundreds (if not thousands) of seeds and/or they have extensive root systems. Unfortunately, a number of these invasive weed species are increasing in quantity, area of infestation, and density.

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Table of Contents

1. **Doing Science**
   - **3-5th activities**
     Activity 1 An Ecosystem is Like a Bowl of Milk bowl of milk
     Activity 2 How Many Drops of Water on a Penny?

   - **6-8th activities**
     Activity 1 Introduce The Wheel of Logic
     Activity 2 How Many Drops of Water on a Penny?

2. **Invasive Weeds "101"**
   - **3-5th activities**
     Activity 1 **Invaders Uncovered (Powerpoint on CD)**
     Activity 2 Making a 'Noxious' Field Guide
     Activity 3 Who's Who?
     Activity 4 Weedy Critters

   - **6-8th activities**
     Activity 1 A Weed by Any Other Name. . ..
     Supplemental Materials PowerPoint
     Activity 2 Glacier National Park – Invasive Plants Citizen Science Online Training
     Glacier National Park - **Invasive Plants Citizen Science Online Training**
     (Pages 1-46)
     Activity 3 Making a 'Noxious' Field Guide
     Activity 4 Who's Who?
     Activity 5 Plant Investigation
     Activity 6 The Great Race for Survival The Great Race for Survival

   - **9-12 activities**
     Activity 1 A Weed by Any Other Name. . ..
     Supplemental Materials PowerPoint
     Activity 2 Glacier National Park - **Invasive Plants Citizen Science Online Training**
     (Pages 1-46)
     Post Activity Invasive Plant Quiz
     Activity 3 Virtual Survey of Invasive Plants Virtual Survey of Invasive Plants
     Activity 4 **Biological. . .Control?: Tweaking the Ecological Web**
     Biological. . .Control?: Tweaking the Ecological Web
     Activity 6 Biological. . .Control?: Cascading Effects of Biological control of Knapweed
     Biological. . .Control?: Cascading Effects of Biological control of Knapweed
     Activity 8 Pulling Together Pulling Together

3. Invasive Weed Investigations

- **Grades 3-5**
  Plant Investigation

- **Grades 6-8**
  Field Trip to Glacier National Park, Plant Invaders – Citizen Science
  http://www.nps.gov/glac/forteachers/classrooms/plant-invaders-citizen-science-field- trip.htm

- **Grades 9-12**
  Field Trip to Glacier National Park, Plant Invaders – Citizen Science
  http://www.nps.gov/glac/forteachers/classrooms/plant-invaders-citizen-science-field-trip.htm

4. Stewardship

- Glacier National Park Citizen Science Project
  Glacier National Park Citizen Science Project

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Laura Law,
Educational Specialist
Glacier National Park

Introduction to Curriculum

This curriculum is designed for teachers who want to integrate the topic of invasive weeds in the classroom, develop weed awareness, and provide students in grades 3 to 12 with an understanding of the serious problem of invasive weeds.

Invasive plants are the "outlaws" of the plant world. They may be pretty, but they are out of place and up to no good. From a distance, weeds do not seem so bad, but take a closer look and you will see them choking out the native wildflowers, grasses, and shrubs. These native plants protect the soil, attract and sustain a variety of wildlife, and add to the park's biodiversity.

The flora of Glacier includes 1050 plant species, with 126 being non-native plants. Many of these non-natives are ornamental species, although 16 are considered invasive. Some of the most troublesome invasive non-native weeds include: spotted knapweed, leafy spurge, oxeye daisy, St. Johnswort, and orange hawkweed. The most aggressive weeds spread into grasslands and forests, reducing wildlife habitat, increasing soil erosion, and diminishing the diversity of park flora.

Students need to understand invasive plant issues within their community, be aware of the environment's level of health, and recognize factors that influence the environment's health. This knowledge will allow students to make informed decisions regarding development, pollution, land management, and other factors that affect the quality of our life and our environment.

By participating in handson activities, students will learn the scientific method, why invasive weeds are a problem, how to identify weeds, how to conduct a weed inventory, and methods of controlling weeds in their community and in Glacier National Park.

Activity 1 – An Ecosystem is Like a Bowl of Milk

(15 minutes)

Materials

- Warm milk
- Large shallow bowl or flat-bottomed container (5 cm deep)
- Food coloring
- Liquid dish detergent
- Toothpicks

Procedure

1. Explain to students that an ecosystem includes all the living (biotic) and non-living (abiotic) elements that interact with each other in a particular area. Name different components of a forest ecosystem to reinforce understanding *(trees, flowers, berries, snakes, birds, mice, deer, mountain lions, rocks, soil, etc.)*.

2. Tell students that although ecosystems are always changing, scientists have come to understand that they change in somewhat predictable ways. But scientists have also come to understand that ecosystems can be fragile. When one or more pieces of the ecosystem or species that live in the ecosystem are lost or damaged, the ecosystem does not function as it should. Tell students they are about to see what happens to a healthy ecosystem when its pieces are damaged.

3. Pour warm milk into a large, shallow bowl or flat-bottomed container at lest 5 cm deep. Explain the sides of the bowl represent the boundaries of the ecosystem. The milk represents the abiotic, or non-living, elements of the ecosystem.

4. Add drops of different colors of food coloring to the milk in different locations. Explain that the different colors represent the biotic, or living, elements in the ecosystem. *Note: different colors can represent different types of organisms such as green represents plants, red represents mammals, etc.* The biotic organisms include populations of different plant and animal species that evolved over thousands of years to fill different roles (niches) in the ecosystem.

   Ask students to observe how the drops of food coloring (populations of biotic organisms) grow or expand slowly to fill the available space. Explain that organisms have changed slowly over thousands of years. Organisms look the way they do today because they have adapted perfectly to their environment and developed desirable traits that enable them to survive in their environment.

   Organisms continue to change form in response to gradual changes in their environment, but very, very slowly. When environments change quickly, organisms (plants and animals) cannot keep pace with the change.

5. Tell students that we are going to introduce an alien or invasive species to the ecosystem. They should watch carefully and notice the type of changes and the rate of change in the ecosystem. Have students take turns adding a drop of liquid dish detergent to the surface of the milk by dipping a toothpick into dish detergent and then touching it to the surface. Ask them to observe the changes; changes will be rapid, and many.

6. Allow the ecosystem to react for at least five minutes. Over time, the colors will mix and disperse; the pan will appear more homogeneous and less colorful. Suggest that the invasive species reduced diversity as they out-competed the native species. Ask students which ecosystem was more attractive, appealing, or full of life.

Adapted from Alien Invasion's "Plants on the Move."

Assessment

- Ask students to define what an ecosystem is. List several types of ecosystems and discuss what types of invasive species might affect each. How might invasive species cause problems for native plants and animals?

Activity 2: How Many Drops of Water on a Penny?
(20-25 minutes)

Materials

- Pennies, water, eyedroppers, and small containers (enough for class)
- "*How Many Drops of Water on a Penny?*" worksheet

Procedure

1. Introduce students to using the scientific method by having them analyze the question, "How many drops of water fit on a penny?" Pair students together and provide each group with a penny, an eyedropper, a small container, and the "How Many Drops of Water on a Penny?" worksheet.

2. Have students analyze the question, "How many drops of water fit on a penny?" and make a hypothesis, or educated guess, for the question such as, *"If more than 10 drops are put on the penny, then the water will drip off."* Have them write their hypothesis on their worksheet.

3. Putting the penny in a small container, and using the eyedropper provided, they will add drops of water to one side of the penny (facing up) and count the drops added, until the water runs off the penny. Students will then record the number of drops on their worksheet.

4. Students will repeat the testing at least two more times and record the data in the appropriate blanks. After they are finished testing, each group will compare their data to their hypothesis and write a brief conclusion.

5. If time permits, ask each group to come up with variables that may affect the number of drops that can be placed on a penny. *Some examples include: the temperature of the water, the head or tail side of the penny, or different eyedroppers.* Each pair will then write their hypothesis for that particular variable and proceed with testing and recording. An example of a possible hypothesis is "If we put drops of water on both the head and tail side of a penny, the number of drops on the tail side will be greater." Repeat testing should be encouraged as well as providing a new conclusion.

How Many Drops of Water on a Penny?

Name: **Date:**

After you and your partner receive a penny, eyedropper, and container investigate the surface of your penny. How many drops of water do you think will fit on your penny? Make a **hypothesis**, or educated guess, for the question. Write your hypothesis in the space provided.

Now it's time to test your hypothesis! Put the penny in the container and, using the eyedropper, add drops of water to one side of the penny (facing up). Make sure to correctly count the number of drops it takes until the water begins to run off the penny. Record this number in the blank below. Repeat your investigation two more times and record the data in the appropriate blanks.

Hypothesis: _____

_____.

Experiment 1 Results: _____ # of drops

Experiment 2 Results: _____ # of drops

Experiment 3 Results: _____ # of drops

Conclusion:

Compare your data to your hypothesis. What can you conclude about your educated guess? Write a sentence or two explaining what happened.

_____

_____

Extra Credit:
Can you think of some things that might affect how many drops can fit on a penny? Would the temperature of the water change the results? Does it matter if it's the head or tail side of the penny? Changing one thing in the experiment is called adding a **variable.**

Think of what you want to change and then write it down on the blank next to the word "variable." Make your educated guess, or hypothesis, for the new experiment. Don't forget to repeat your experiment!

Variable _____

Hypothesis: _____

_____.

Experiment 1 Results: _____ # of drops

Experiment 2 Results: _____ # of drops

Experiment 3 Results: _____ # of drops

Conclusion:

Compare your data to your hypothesis. What can you conclude about your educated guess? Write a sentence or two explaining what happened.

_____

_____

Plant Invaders Activity

Invaders Uncovered Slideshow

Slide 1
We are going to learn a lot more about "alien" or invasive species when we head to Glacier National Park for our field trip. Many of you have been to Glacier before on previous field trips, but on this field trip we will not only get to explore the park, we will also conduct actual scientific research!

Slide 2
Glacier has many different kinds of critters within its million acres of land. Who know what the animal on the left is? *(picture of moose)* What about the little animal hiding in the rocks? *(picture of pika)*

Slide 3
In fact, Glacier's ecosystem is full of diversity! That means that there are a lot of plants and animals here. From huckleberries to bears, we are lucky to have so many neat animals and plants where we live.

Slide 4
Let's just make sure we know some important words. An **ecosystem** is all the living and nonliving things in a certain area and the relationships they have with one another. **Diversity** means there are many different types, or kinds, of plants and animals living in one area *(give examples of types of plants/animals…huckleberries, roses, strawberries, grizzly bears, mountain lions, etc.)*.

Slide 5
Sometimes certain plants or animals can come into an ecosystem and take over, or spread quickly. We call these species "invaders." They are dangerous because they can replace native plants/animals and cause less diversity in an area.

Slide 6
When these invaders come in, native plants move out! And that means we could loose important habitat for native plants, even special yummy plants like huckleberries.

Slide 7
There are certain plants that are really good at spreading and taking over an area. These plants are able to not only change how a place looks but can also change the habitat in that area. This can be devastating for native plants and animals.

Slide 8
We call these extremely competitive invaders, noxious weeds. The state of Montana lists over 30 of these invaders as noxious weeds. Not all of them are found in Glacier National Park but there are a bunch of them found in and around the park boundaries. Learning them all would require a lot of time so we will study four noxious weeds found commonly in our area.

Slide 9
Spotted knapweed is a common noxious weed found along roads and in open areas. It is often found in our towns and yards as well as in places like Glacier. Look for its pinkish-purplish flowers and its brown, triangle-shaped bracts, or leaves, found under the flower. These bracts make the plant look spotted, which is how it got its name!

Slide 10
Oxeye daisies are pretty to look at. They have white ray flowers surrounding a yellow center. Oxeye daisies are often found in fields and along roadsides. They spread very quickly since they can make new plants from lateral roots, or roots that go sideways, underneath the ground. This can be bad for horses, cattle, and wildlife, all of which are unable to eat them.

Slide 11
Houndstongue can grow up to four feet tall. It is found more often in the forest than in open areas. The plant got its name because its leaves look like the surface of a dog's tongue. Have you ever gone into the woods and came out with a bunch of little sticky seeds on your socks or pants? If so, you probably ran into some houndstongue plants. The seeds of the plant are able to stick to fur and clothing, which is how the plant spreads its seeds.

Slide 12
St. Johnswort is another plant that came from Europe. It is a pretty plant with five-petaled yellow flowers. Its leaves are small and have tiny transparent, or see-through, dots in them. This helps to identify the plant. Many people like this plant because it can be used as medicine for ailments such as depression as well as burns and skin disorders.

Slide 13
Noxious weeds have many different strategies, or "adaptations," that help them beat out the native competition. These special strategies were developed in their homelands in order to help them survive. Here, in our forest ecosystem, these **adaptations** allow them to beat out native vegetation. *Point out a few of the adaptations on the slide. Be sure to keep it short for younger students.*

Slide 14
Even with those helpful adaptations, most noxious weeds need a little help to spread. More than anything, weeds can take hold and spread when the landscape has been disturbed. A disturbed area is when a part of the ecosystem has been changed very quickly.

Slide 15
Sometimes this change is natural. What happened here? That's right; a forest fire went though here. Seeds from noxious weeds are transported to burnt areas via fire trucks, people's shoes and clothing, and clean-up equipment. Even though fire is a natural component of the forest ecosystem, the rapid change to the forest makes it easier for noxious weeds to grow and spread.

Slide 16
Noxious weeds also spread through the actions of people. Construction of new homes, buildings, and roads can create heavily disturbed areas. Although construction isn't a bad thing, we need to be careful when we change the landscape because it's a perfect opportunity for noxious weeds to come in and take over.

Cars and trucks are another way in which people help to spread noxious weeds. The car in the picture is traveling along the Going to the Sun Road and although it looks innocent enough, there is a good chance it has noxious weed seeds stuck to its tires or body. These seeds can fall off along the roadside and begin to grow and spread.

Slide 17
Whether it's a natural change or a change caused by people, noxious weeds love disturbed, or changed places!

Slide 18
But why am I telling you all of this? Who cares? One big concern is that both wildlife and livestock cannot eat most of these plants. Animals have adapted to eating native plants. Since most noxious weeds do not provide nutrients for the animals that live here, more weeds means less food for wildlife.

Slide 19
That's why we monitor them and research them. We want to try and reduce their rapid spread.

Slide 20
And when you come to the park, you will learn about and research weeds too!

Slide 21
We will use the scientific method when we do our research. That means we start by asking a question (in this case a question concerning noxious weeds), doing some background research, making an educated guess on what we expect to find, and finally going out to the field and collecting our data.

Slide 22
But besides conducting a science experiment, we will have lots of fun!

Slide 23
Who's ready to begin our investigations?

Activity 1 – Invaders Uncovered
(20 minutes)

Materials

- CD – Invaders Uncovered

Procedure

1. Using the provided PowerPoint presentation, give students an overview of featured noxious weeds found in Glacier National Park and the scientific method. *An outline of the slideshow accompanies the CD and is found in the materials provided.*

2. At the end of the slideshow, tell students that they will be studying the noxious weeds seen in the presentation.

3. Remind students that in the previous presentation, students learned how noxious weeds can limit (or take away) diversity in an ecosystem. They also were told some of the human-related factors that allow these weeds to spread. Knowing what they do, ask students why scientists might want to study noxious weeds. How would understanding these weed species help Glacier National Park staff?

Assessment

- Guide students into creating a hypothesis that identifies the disturbed site as most likely having a greater number of weeds. **The following hypothesis is an example. "If there is an area that has been disturbed, then we will see more noxious weeds."** Write this hypothesis on the board and make sure students include this in their field guide.

Activity 1 – The Scientific Method: The Wheel of Logic
(20 minutes)

Materials

- Wheel of Logic Handouts

Procedure

Explain to students that the process used by scientists as they pursue research can be thought of as a wheel with questions at the hub and various stages of the inquiry in a circular arrangement around the hub. It is noted that the process of scientific inquiry can begin from any stage and that stages may be revisited as often as the particular inquiry requires.

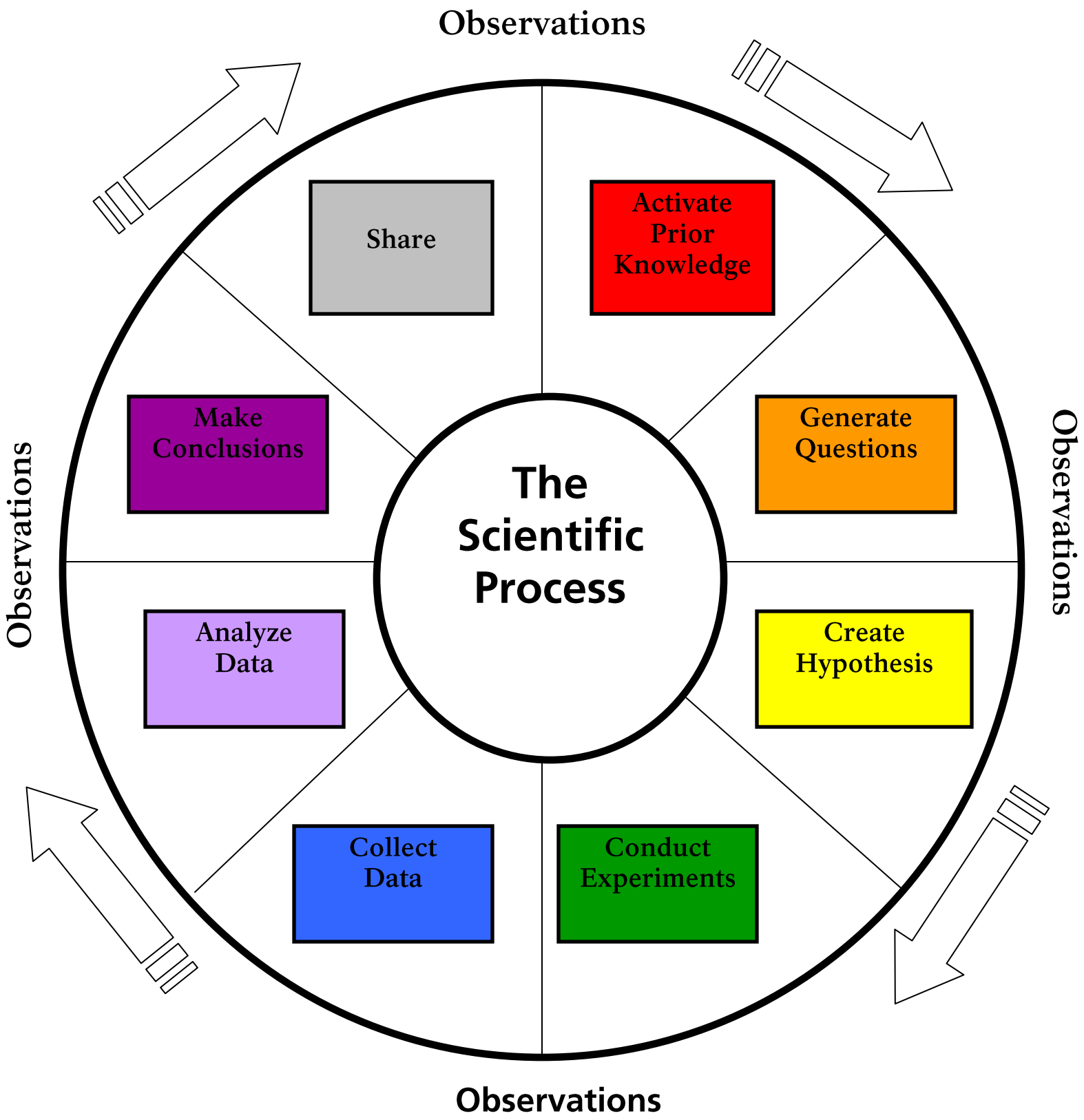
- The scientific method is a way to ask and answer scientific questions by making observations and doing experiments.
- The steps of the scientific method are to:

    - **Ask a Question**
    - **Do Background Research**
    - **Construct a Hypothesis**
    - **Test Your Hypothesis by Doing an Experiment**
    - **Analyze Your Data and Draw a Conclusion**
    - **Communicate Your Results**

- It is important for your experiment to be a fair test. A "fair test" occurs when you change only one factor (variable) and keep all other conditions the same.

Assessment

Students will conduct the experiment, How Many Drops of Water on a Penny.



The Wheel of Logic

Modified from the Teton Science School and Evergreen Teacher Vic Dalla Betta

Welcome to Glacier!

A Place for All Things…Big & Small

With over 1,000 plants and 70 animals, Glacier has an ecosystem full of diversity!

Definitions

- An ecosystem is a complex set of relationships between living and nonliving things.

- Diversity means there are many different types of plants and animals living in one area.

Watch Out for the Invaders!

Some plants and animals are called “invaders” because they move in to an area and take over. This causes less diversity in the ecosystem.

When Invaders Come In, Others Move Out

⇨

Plant Invaders

- Some plants that move into an ecosystem from someplace else are VERY dangerous to the rest of the ecosystem. They can take away habitat from other plants.

Houndstongue

They're Noxious!

- We call these especially competitive invaders noxious weeds.
- There are a bunch of noxious weeds in Montana and several in Glacier National Park.
- We are going to study four of them.

Spotted Knapweed

Oxeye Daisy

Houndstongue

St. Johnswort

Beating the Competition!

Noxious weeds are good at beating out other plants because they…

1) Are able to live in many different climates and types of soils.

2) Produce a lot of seeds in a short period of time.

3) Can grow new plants from roots as well as seeds.

4) Have long roots that allow them to get the water and nutrients before other plants can.

5) Some weeds can even stop other plants from growing around them!

A Little Help Goes a Long Way!

- Even though noxious weeds are good competitors, they spread faster when helped.
- Weeds love disturbed areas.
- Disturbed areas are ones that have had rapid changes to the ecosystem.

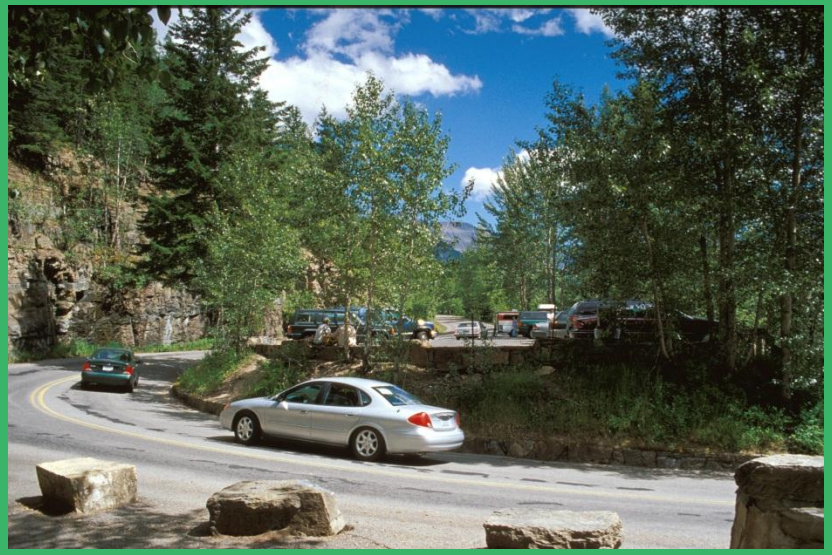
Some Help is Natural. . .

Like this forest fire.

Some Help Comes from People

Construction of
Homes and Buildings

Roads and Vehicles



Either way, noxious weeds are good at moving into places that have been disturbed!

So What?

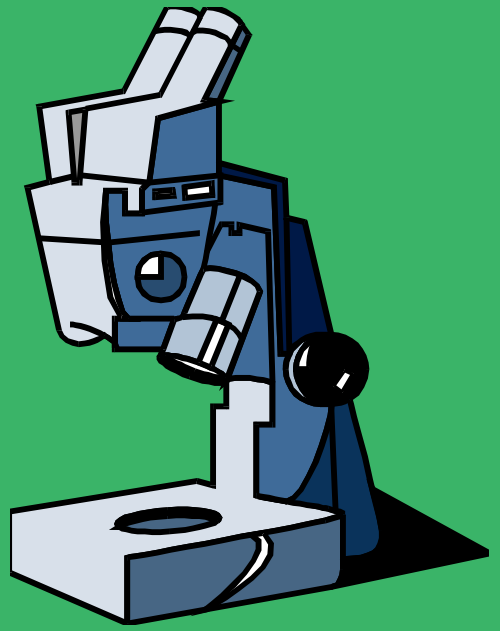
- Animals have adapted to eating native plants.
- Most noxious weeds do not provide any food for the animals that live here.
- More weeds means less food for wildlife.

That's Why We Research Them

And You Will Too!

Just Like Real Scientists, We'll Use the Scientific Method

- Question
- Research
- Hypothesis
- Conduct Experiments
- Collect Data
- Analyze Data
- Make Conclusions
- Share



We'll Also Learn About Weeds and Have Fun Too!

Let's Begin our Investigation!

Activity 2 – Making a 'Noxious" Field Guide

(30-40 minutes)

Materials

- Make copies of the "Plant Invaders Field Guide" pages and hand out to each student (total of three double-sided pages).
- Boxes of colored pencils

Procedure

1) Students can begin creating their journals by putting the pages in order from 1-3, beginning with **page one on the bottom.** Have students fold their pages to form a booklet…folding left to right. Bind field guides together using three brass fasteners or staple in the middle.

2) Place students in groups of three or four, depending on class size. Give each group a set of the Noxious Weed Fact Cards. Tell students to use the fact cards to create their field guides. Each student will need to accurately color all three weed species, write the name of each plant at the bottom, label the flowers, leaves and stems of each plant, and write down three interesting facts about each weed species.

3) If time permits or if finished early, students can draw or paste a picture on the cover of their field guide.

Plant Name _____

Notes

Glacier's Plant Invaders Field Guide

Name _____

My Favorite Plant

Plant Name _____

Notes

Directions

Using the Noxious Weed Fact Cards to help you, identify which plant is drawn on the opposite page. Write the correct name of this plant on the space provided. Then label each blank with the correct plant part (flower, leaf, or stem).

In the space below, write three fun facts about this plant.

Fun Facts

1) _____

_____

2) _____

_____

3) _____

_____

Draw this plant's seeds in the box.

Plant Invaders—Citizen Science

Program Objectives

Grade: 6-12
Subject: Science
Skills: Observe, communicate, identify, classify, record
Duration: 4 hours
Group Size: 45-60 total, 2 groups of 20 -30 students.
Setting: First 2 miles of lower elevation trails in the park.
Vocabulary: See the **bolded** words in the objectives below.

Summary
Students will become "Citizen Scientists" and hike less than 2 miles to permanently established research plots to collect data on the percent cover of native and non-native, invasive plants. Students will return to school and enter their information into a Google Document to add their data to the information from previous visits of other schools. They will analyze and look for patterns as the database builds each year.

Objectives
(These are examples of some of the objectives that can be achieved on a forest walk. Many others are possible depending on the teacher's focus and the ranger.)

Students will be able to:

- Tell what **national parks** protect and one reason Glacier National Park was established.
- Explain why Glacier National Park is concerned about the spread of **non-native, invasive plants** and the loss of **native plant communities**.
- List 3 native plants and their uses by wildlife and people (including traditional uses by the **Blackfeet, Salish, Kootenai,** or **Pend d'Oreille**).
- Use a field guide to identify four different species of non-native, invasive plants classified by the state as "**noxious weeds.**"
- Work cooperatively with classmates to locate and record data on the occurrences of the four targeted non-native, invasive plants along the assigned trail.
- Use a **GPS** to locate permanent vegetation transects to record data on non-native, invasive plants.
- Use a **topographic map** to **correlate** historic information about infestations and past **treatments** of non-native, invasive plants along the trail.
- Accurately complete a **data sheet** for recording **observations** of **percent cover** of non-native, invasive plants following the established **protocols.**
- Define "**Citizen Science**" and give 1 reason national parks are training people to collect data in parks and 1 reason many scientists don't think this is "real" science.
- Explain why Glacier does not ask all visitors to pull non-native, invasive plants whenever they see them.
- Input data into an Excel spread sheet and analyze it to formulate a plan for management.
- **Recognize patterns** from the **data** collected on the trail and **infer** why non-native, invasive plants may be found more commonly in some areas of the park than others.
- Identify non-native, invasive plants in the local community and research local and state regulations about what is being done, and what more could be done, to control their spread.

Plant Invaders—Citizen Science (Grades 6-12)
Program Objectives continued

Montana Content and Performance Standards:
MT.SCI.K-12.1 Students, through the inquiry process, demonstrate the ability to design, conduct, evaluate, and communicate results and reasonable conclusions of scientific investigations.
MT.SCI.K-12.3 Students, through the inquiry process, demonstrate knowledge of characteristics, structures and function of living things, the process and diversity of life, and how living organisms interact with each other and their environment.

Making Connections to Glacier National Park:
Glacier National Park covers an area that is a crossroads between three floristic provinces with numerous native species on the edges of their ranges. The spread of non-native, invasive plants threatens native communities and the actions of people are key to assisting in reducing their spread.

Field Trip Logistics:
Teachers wishing to have their students participate in the "Plant Invaders" field trip should plan to arrive at the Apgar Area by 10:00 a.m. and stay until 1:30 p.m. Everyone in the group must be prepared to be outside for the entire program and able to hike up to 4 miles over varied terrain.

Plant Invaders—Citizen Science (Grades 6-12)
Typical Field Trip Schedule

Flexibility for weather conditions, bus problems, etc…is essential to having an enjoyable visit to the park. No two school programs are exactly alike, but the following schedule represents a typical trip.

8:30 a.m. – 9:30 a.m. Travel to the Park
Simple assignments can be completed by seatmates or individuals during this time. Point out sights along the way that relate to the park story such as mountain uplifting, glacially carved valleys or mountain passes, plant communities, river crossings, and canyon formations. You may also want to review vocabulary words or ecological concepts.

9:30 a.m. – 9:45 a.m. Meet park rangers at the Apgar Transit Center.
After a brief welcome by the park rangers to Glacier National Park, the ranger(s) will talk with the chaperones and teacher(s) about the schedule for the day, students will take a bathroom break.

9:45 a.m. – 10:15 p.m. Stations
Students should be in groups of 3. There will be 6 stations set up and 3-4 of the student groups will be at each station. Students will review information about non-native, invasive plants and their identification.

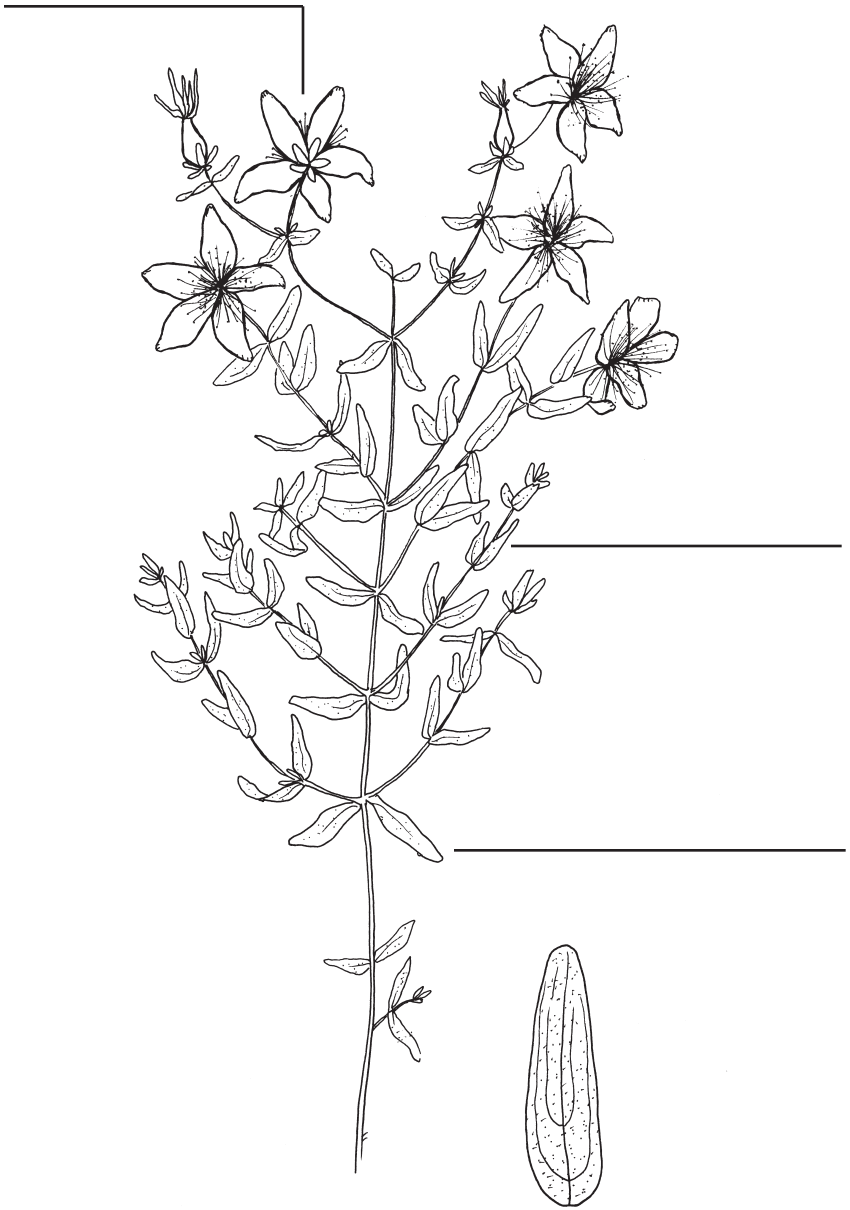
10:15 a.m. – 12:15 p.m. HIke
Station groups will hike with their assigned rangers/volunteers to their monitoring site and collect data on percent cover of non-native, invasive plants.

12:15 - 12:45 p.m. Lunch and clean-up
(lunch spot to be decided by ranger and teacher depending on which trail the students hike on).

12:45 – 1:30 p.m. Pull Weeds
Students pull weeds (mechanical treatment) if possible. Students must be signed up as volunteers in advance and have gloves. Ranger(s) review the educational objectives for the day.

1:30 – 1:45 p.m. Both classes meet back at the Apgar Transit Center (if others went on a different trail) and compare results. Final bathroom breaks and load up buses.

2:00 p.m. Bus leaves the park



Plant Name _____

Directions

Using the Noxious Weed Fact Cards to help you, identify which plant is drawn on the opposite page. Write the correct name of this plant on the space provided. Then label each blank with the correct plant part (flower, leaf, or stem).

In the space below, write three fun facts about this plant.

Fun Facts

1) _____

_____

2) _____

_____

3) _____

_____

Draw this plant's seeds in the box.

Weed Critter Drawing

Directions

Using the Noxious Weed Fact Cards to help you, identify which plant is drawn on the opposite page. Write the correct name of this plant on the space provided. Then label each blank with the correct plant part (flower, leaf, or stem).

In the space below, write three fun facts about this plant.

Fun Facts

1) _____

_____

2) _____

_____

3) _____

_____

Draw this plant's seeds in the box.

Activity 3 – A Tough Competitor

(15 minutes)

Procedure

- Introduce the idea that non-native invasive plants might be able to take over a native plant community by playing a game of "Native vs. Non-native Tag."

- Explain to the group that non-native invasive plants, or noxious weeds, have many strategies that allow them to out-compete native plants. Since they came from someplace else, they also do not have some of the systems in place like native plants to control their spread.

- Have boundaries for the tag game previously set up. Explain to the students that they will need to stay within those boundaries or they will turn into noxious weeds.

- Ask for one volunteer to be a non-native invader while the rest are native plants. Allow native plants to hop around in a circle but tell them they cannot move around the playing field. The non-native invader can move by hopping forward or side to side. He or she will try to tag other students. Once a student is tagged, they will link arms with their tagger and become a non-native invader themselves.

- When the link of students gets to four, they will break off into two's, this keeps the game more active as well as increases the mobility of the non-native invaders.

- Once all native plants are removed from the system, the game is over.

- *It's interesting to play this game more than once. Try ending the game when there are just a few remaining native plants. Usually the last "native plants" to get tagged are on the periphery of the playing field, which is somewhat similar to a real life scenario.*

Activity 4 – Weedy Critters
(15-20 minutes)

Materials

- Drawing Paper
- Boxes of colored pencils

Procedure

1) Ask students to list some strategies, or adaptations, that weeds have in order to survive. Be sure to prompt students to name some adaptive characteristics of weeds, which make them so successful. *Several examples include: able to live in a wide range of climate and soil conditions, produce many seeds rapidly and as long as the growing season permits, many weeds can produce from roots as well as seeds, have long roots that allow them to get to water and nutrients, and able to stop other plants from growing around them by emitting a chemical into the soil.* What factors are missing from the weeds' homeland, which keep these plants in check?

2) Tell students that they will have the remaining time to draw an imaginary weed/plant that possesses as many of these characteristics as possible. After several minutes, ask if there are any volunteers who would like to share their drawings with the rest of the class.

LESSON 13

A Weed by Any Other Name …

Grade level: 6-12
Subject Areas: Biology
Duration: 1-2 class periods
Setting: Classroom
Season: Any
Conceptual Framework Topics: Plant ecology, habitats, invasive species

OBJECTIVES

Students will understand the meanings of the terms *weed, native, non-native, invasive,* and *noxious*. They will learn why invasive plants cause ecological damage and affect humans.

METHOD

Students watch a slideshow (PowerPoint) that challenges them to consider and discuss examples of non-native ("out of place") species, some of which are considered weeds, some of which are invasive and noxious. They discuss how these terms are applied to different plant species, and how context and perspective influence how and when they are used.

MATERIALS

- ✎ Introductory PowerPoint from the *kNOweeds Guide* CD or at **http://missoulaeduplace.org/weeds_curriculum.shtml**
- ✎ White or chalk board for brainstorming

BACKGROUND

There are many terms used to describe plants growing in ways and places that are undesirable to people. Some of these terms are used interchangeably by some people while others make very clear distinctions among how the words are used. This may create misunderstanding or confusion among those attempting to manage plants, let alone someone just beginning to learn about the subject!

Weed is a subjective word used to describe any plant growing where it is not wanted, for various reasons.

The term *native* (or *indigenous*) is applied to species that are growing in a region where they occur without having been transferred there through direct or indirect human actions. These species have adapted to the environmental conditions of their native range, including the influence of other species, through thousands or millions of years. (Species living in North America prior to European settlement are generally considered native.) *Non-native* species (also referred to as *alien, exotic, foreign, introduced,* or *non-indigenous*) are those growing outside of their known native, natural or historic range. A non-native species may be from another continent, another part of the same continent, or even from a different part of the same region. For example, in Montana there are non-native species that are from other continents (e.g., Russian knapweed), other parts of North America, and different parts of the Rocky Mountains

(e.g., Colorado blue spruce). Some plants are introduced intentionally, as ornamentals, livestock forage, windbreaks, or to improve wildlife habitat. Others are transported unknowingly by being mixed with other plants or seeds, or adhered to vehicles, shoes, clothing, livestock, pets, or other mobile items.

Many non-native species do not grow well in their new habitat because they have not adapted to the particular conditions present there. In Montana, for example, many species may not be able to survive the low moisture levels found in Montana soils throughout much of the growing season, or they may not tolerate the extreme cold temperatures during the winter. These species may not survive at all without assistance from humans, or they may grow only near water sources or in especially sheltered sites.

Other introduced species, however, come from similar habitats and are well-adapted to the growing conditions found in their new range. Some of these species are also "freed" from the predators, diseases, or close competitors of their native range, and may spread rapidly and displace other vegetation. These are considered *invasive*. The National Invasive Species Information Center (NISIC) defines *invasive* thus:

An 'invasive species' is defined as a species that is 1) non-native (or alien) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions.

The application of the term invasive, like that of weed, is somewhat subjective and depends on variable human values.

Noxious weeds are invasive plants that have been given special designation through a state or federal law. These laws are designated to protect agricultural production and natural areas by mandating and regulating the control of invasive plants.

Why should we care about invasive plants? Invasive plants can:

- Reduce agricultural production, including livestock forage
- Displace native vegetation, including rare plants
- Degrade or eliminate habitat for wildlife
- Increase soil erosion
- Alter the frequency and intensity of fires
- Alter hydrologic regimes and degrade water quality and fish habitat
- Decrease ecosystem stability by lowering biodiversity and interrupting natural processes and interactions among species

PROCEDURE

1. Begin the ***Introduction to Weeds*** PowerPoint and encourage your students to consider and discuss the concepts and terms introduced. Use the following notes for each slide to encourage the discussion.

Slide No.	Notes
1.	Discuss that they are all growing in places most people would not want them to grow. They are "out of place." If the term "weed" doesn't come up, ask students if they consider them weeds. Ask for their definitions of a weed.
2.	Discuss the subjective nature of the word "weed" and how its meaning might vary from person to person, depending on perspective.
3.	Ask them to describe what they see. What's funny about this picture? Why? Where would this plant usually grow? Have they heard of native species?
4.	Discuss the terms native and indigenous.
5.	Discuss non-native species and then ask students how non-native plants might be introduced to a new place. Brainstorm a list.
6.	Did they think of all of these modes of introduction? Have they thought of others not on this list?
7.	Ask them what they notice about this large picture. Explain that these are also non-native plants. They differ from the ones in the desert picture they just saw because they are well-adapted to where they are growing, since they came from (evolved) in a similar place, or habitat. Are they considered weeds? Remind them of the definition. It depends on the perspective.
8.	Discuss the differences between non-native plants like knapweed and garden flowers. In one case, the non-native plants are invasive—they are taking over, or invading, the other vegetation around them and they are identified as invasive plant species by land managers. In the garden photo, they are simply non-native, introduced, or exotic species which, at least at this time, do not seem to pose any threat to the landscape.
9.	Ask what might make a plant invasive. Brainstorm ideas.
10.	Did they think of all of these points? Now ask what kinds of traits they think might make a plant successful at invading a new area. Make a list.
11.	Discuss.
12.	Discuss. Now ask if they have heard of the term "noxious weeds". Can they deduce what it means?
13.	This is the only one of these terms that has any legal meaning.
14.	Noxious weeds have been spreading rapidly for the past 100 years. For example, spotted knapweed arrived on the west coast in 1893 on the San Juan Islands in Washington. By 1920, this weed had established in over 24 counties in three northwestern states, with several large infestations near Missoula. Now, spotted knapweed has been reported from every county in the western United States and has invaded about five million acres in Montana alone.
15.	How many Noxious Weeds of Montana can your students name?
16.	Can your students identify any of these plants? Why might it be important? Besides being legally responsible for controlling noxious weeds, why should they care about invasive plants? Can they think of problems invasive plants might cause? Brainstorm a list.
17.	Did you think of all these? Discuss these problems caused by invasive plants.
18.	Discuss these problems caused by invasive plants. Are there more?
19.	Can your students think of personal reasons to care about invasive plants? Are there places they like to go that have been invaded by noxious weeds? What can they do personally to help prevent the spread of invasive plants?

2. Next, discuss in small groups or as a class the following scenarios:

- You work for the U.S. Department of Agriculture, and a nursery company requests approval to bring a new species of plant into the U.S. for use as an ornamental plant. What kinds of questions would you want to ask about this plant to determine if it is likely to become invasive?

- You are conducting a survey to discover the distribution of an invasive plant species that colonizes disturbed areas and has just entered your county. Draw a diagram or map of where you would expect it to occur. Now, assume it is 15 years later and no one has tried to control this species. How has its distribution changed? Draw an updated map of its distribution. Would the distribution be different if control measures had been taken?

3. Have students research one of the noxious weeds of Montana, using resources listed in this guide or others. They can create an invasive species profile using the attached worksheet or their own ideas. You might want to expand it into a small poster requirement with class presentations.

Name _____

Invasive Plant Profile

Species:

Country or area of origin:

How was it introduced to the U.S.? To Montana?

When and where was it introduced?

What is its current distribution in the U.S. and in Montana?

What characteristics make it a successful invader?

What kind(s) of habitat does it live in?

Does it invade only disturbed areas or also undisturbed sites?

Does it seem to outcompete or displace other plants where it invades?

Does anything in Montana eat it? If so, what?

What problems does it cause where it invades?

Are there successful measures to control it? If so, what are they?

Is it being controlled locally?

Crown of the Continent
Research Learning Center

National Park Service
U.S. Department of the Interior

Glacier National Park

Glacier National Park's Invasive Plant Citizen Science Training Program

http://www.nps.gov/glac/naturescience/ccrlc-citizen-science_weeds.htm

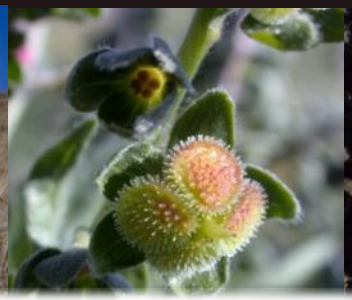
NPS photo

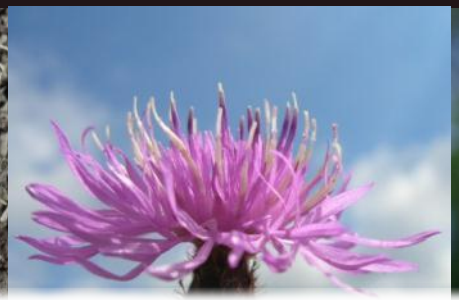
Crown of the Continent
Research Learning Center

National Park Service
U.S. Department of the Interior

Glacier National Park


N Rees, Invasive.org






L. M. Landry

Glacier National Park's Invasive Plant Citizen Science Quiz (at end of on-line training)


L. M. Landry


M. Lemmer, www.naturkamera.de


W. Eigelsreiter

Activity: Classroom Plant Investigation
(30-45 minutes)

Materials

- Field Guide from previous assignment
- Colored Pencils

Procedure

1) After identifying what students already know about each weed in the previous activities, students will then investigate each of the four noxious weed species in detail.

2) Students will break into five groups of five. Each group will get one of the four identified noxious weeds (1 weed species will be duplicated). The groups will look at the pressed leaves, flowers, stems, and roots of their plant with hand-lenses. Each group will also get a card with the picture of their plant on one side and interesting facts on the other.

3) Point out the Plant Investigation Station Instruction Card found within each investigation station packet. The card provides instructions but it is useful to give verbal instructions as well.

4) Remind students that they must first draw the leaf of their plant in their field guide. Once this is accomplished, students should write down two interesting facts about their plant. As a group, discuss some of the plant's adaptations that help the plant to survive and thrive.

5) Tell students they need to work together to finish the tasks. After they are finished, they will need to decide how they would like to present their weed to the rest of the class. They can create a skit, sing a song, or write a story…students should try to highlight interesting adaptations or facts about their plant.

Extension

Use the noxious weed plot data sheet and see how many weeds are in your school yard!

Plant Investigation Station Instructions

Your job is to do the four following tasks:

1) Draw the leaf of your plant in the "Notes" section of your field guide.

2) Write down two facts about your plant that your group thinks is really neat.

3) Write down one adaptation, or strategy, that your plant has which helps it out-compete other plants.

4) And last but not least, don't forget to investigate! Take a look at all the parts of your plant. Use your hand lenses to look at the fine details of your plant. And have fun!

Now….work together has a group and make a skit about your plant. What do you want the class to know? What's cool or unique about your plant? You will present your noxious weed to the rest of the class!

Plant Investigation Station Instructions

Your job is to do the four following tasks:

1) Draw the leaf of your plant in the "Notes" section of your field guide.

2) Write down two facts about your plant that your group thinks is really neat.

3) Write down one adaptation, or strategy, that your plant has which helps it out-compete other plants.

4) And last but not least, don't forget to investigate! Take a look at all the parts of your plant. Use your hand lenses to look at the fine details of your plant. And have fun!

Now….work together as a group and make a skit about your plant. What do you want the class to know? What's cool or unique about your plant? You will present your noxious weed to the rest of the class!

Activity 5 – Who's Who?

(10-15 minutes)

Procedure

1) Stand (or have parents hold them) four laminated posters of noxious weeds…spotted knapweed, houndstongue, oxeye daisy, and St. Johnswort…in a circle.

2) Place students in the middle of the circle.

3) Tell students to listen carefully to the clues you are about to read to them. You will give students one clue at a time about one of the noxious weeds in the circle. They will have to figure out which plant you are giving them clues about. Once they think they know which plant you are talking about, they can stand by that plant's poster.

4) Give 3-4 clues, waiting between each to see if anyone moves to a poster. Once most students have chosen a poster, tell them they have one more clue to make their final decision. After students have finished moving, announce the correct plant.

National Park Service
U.S. Department of the Interior

Glacier National Park
Montana

Plant Investigation Station Instructions

Your job is to do the four following tasks:

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Now….work together has a group and make a skit about your plant. What do you want the class to know? What's cool or unique about your plant? You will present your noxious weed to the rest of the class!

National Park Service
U.S. Department of the Interior

Glacier National Park
Montana

Plant Investigation Station Instructions

Your job is to do the four following tasks:

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Now….work together has a group and make a skit about your plant. What do you want the class to know? What's cool or unique about your plant? You will present your noxious weed to the rest of the class!

"Who's Who?" Clues

For Oxeye Daisy

1. I am 1-2 ft. high when fully grown.
2. My lower leaves are spoon-shaped and widest at the tip.
3. I'm quite pretty, but I'm not very fragrant. In fact, some say I stink!
4. I have one flower on each stem.
5. My flower center is yellow and I have long white petals.

For Spotted Knapweed

1. I am able to produce over 20,000 seeds on one plant!
2. I bloom in July and August.
3. Many flowers bloom on each of my plants, each at the tip of a separate branch.
4. I have brown, triangle-shaped leaves, called bracts, under each flower. These make me look spotted!
5. My flower is pinkish-purple in color.

For St. Johnswort

1. My seed pods are rust, or orangish-brown, colored.
2. My flowers are about one inch wide and come in clusters.
3. You can see tiny dots on my leaves if you hold them up to the light.
4. Some people use parts of me as medicine for depression, burns, and other skin problems.
5. I have many five-petaled yellow flowers on my branches.

For Houndstongue

1. I have leaves up to 12 inches long at my base.
2. My leaves look velvety but they are rough when you touch them.
3. My flower stem grows 1 – 4 feet.
4. Just like Velcro, my seeds are able to stick to fur and clothing.
5. The top of my branches unroll to show small flowers with 5 reddish-purple petals.

For Spotted Toadflax

1. I can grow as tall as 2 feet.
2. My flowers grow on short stalks in dense clusters at the top.
3. Some think I look like a snapdragon.
4. I am also called butter-and-eggs.
5. My flowers are yellow with an orangish throat.

Activity 6 – The Great Race for Survival

(10-15 minutes)

Procedure

1) Ask students to name some things plants need in order to survive. . .*sun, soil, water, nutrients carbon dioxide, etc*. Make a list on a dry erase board. Can they think of some strategies a plant might have to obtain these resources?

2) Tell students that they will all now become plants in a race for survival. Warn students that not all of them will make it from a seedling to a seed-producing plant. Each student will get one plant species card (a third will be non-natives and 2/3 will be natives). After all students receive a card, have them line up at the starting line to begin the race.

3) Explain to students that they must listen carefully to the directions to know how and when to move. The race ends when two or three plants reach the finish line. Begin reading the Movement Directions. . .according to your statement, students will stay where they are, step forward, or step backward.

4) After two or three students have reached the finish line, read the names of the weeds and ask students to raise their hand if they have a weed species plant card.

5) Ask student to explain what happened during the game. Why did the weed species get to the finish line faster?

6) End the conclusion by explaining to the students that this race was just for fun. . .living organisms often compete for resources, and acquiring those resources could mean the difference between life and death.

"The Great Race for Survival"
Movement Directions

1. Select an open area, such as a gym or playing field, in which to conduct the race. Use cones or rope to designate a starting and finishing line. Position the finishing line about 50 feet from the starting line.

2. Read aloud the following information for students:

Each one of you has been magically transformed into a tiny plant seed. You are many different kinds of seeds from different kinds of plants. All of you have been lying in the soil along the Going to the Sun Road throughout the winter. Some of you landed there by wind, some by water, and some by animals and people. When the road was worked on last year, the construction caused a disturbance in the soil. Conditions are now ideal for weed species to establish themselves. **The events that I will describe represent one year in your life. All of you will not survive the year. Listen carefully to instructions. When I tell you to step forward or backward, take normal walking steps.**

3. It is early spring. Rain, snowmelt, warm temperatures, and long days result in rapid plant growth. Plants send up new shoots from the soil, and seeds that have lain dormant all winter start to sprout, or grow. **Everyone step forward eight steps.**

4. The soil along this new road bed contains many more seeds from some types of plants than others. **Spotted knapweed, St. Johnswort, and Canada thistle step forward six steps. Tansy ragwort step forward ten steps.**

5. A few species are capable of producing chemicals that they release into the soil. These chemicals inhibit the growth of nearby plants. Leafy spurge and spotted knapweed raise your hands. **Any plant within five steps of these plants step backward three steps.** (Leafy spurge and spotted knapweed may step in the direction of those plants they think are within five steps of them. They must count their steps and return to their original positions after doing so.)

6. The growing season continues to be favorable. **All plants step forward six steps.** Several species are able to reproduce new plants from their roots as well as their seeds. This adaptation allows them to quickly expand in number. **Oxeye daisy, St. Johnswort, and Canada thistle step forward five steps.**

7. As the growing season continues, drought hits this area, and plant growth slows. Deep-rooted plants do best. **Leafy spurge, knapweed, and houndstongue step forward six steps.**

8. Summer storms and slightly cooler temperatures improve growing conditions for all plants. **All plants step forward six steps.**

9. Oxeye daisy and St. Johnswort raise your hands. These plants send out long, creeping stems that form a dense mat of vegetation, which chokes out other species within a four-foot radius. **All plants within two steps of St. Johnswort or oxeye daisy step backward three steps.**

10. Plants continue to grow, but shorter days slow growth. **All plants step forward four steps.**

11. Much plant energy is now devoted to food storage and seed production. **All plants step forward two steps.**

12. Some plants release seeds. Those that are able to send their seeds long distances help ensure their success by finding new areas in which to grow. Canada thistle and knapweed are able to take advantage of the wind. Their light fluffy seeds are carried by the wind and spread to new places. **Canada thistle and knapweed step forward seven steps.**

13. Other plants send their seeds long distances by attaching themselves to animals and people that walk by. Houndstongue produces hundreds of seeds each year that easily stick to clothing and fur. **Houndstongue step forward five steps.**

14. End the game after one or more students have crossed the finish line.

The New York Times
nytimes.com

April 4, 2006

A Weed, a Fly, a Mouse and a Chain of Unintended Consequences

By JIM ROBBINS

MISSOULA, Mont. — First came the knapweed. Then came the gall fly. And now the mice population is exploding — the mice that carry hantavirus. In a classic case of unintended ecological consequences, an attempt to control an unwanted plant has exacerbated a human health problem.

Spotted knapweed, a European plant, is a tough, spindly scourge that has spread across hills and mountainsides across the West. In Montana alone, one of the worst-hit states, it covers more than four million acres.

In the 1970's, biologists imported a native enemy of knapweed, the gall fly. The insect lays eggs inside the seed head, and the plant then forms a gall, or tumor, around the eggs. When the larva hatches, it eats the seeds.

Dean Pearson, who works at the Rocky Mountain Research Station of the United States Forest Service, said the fly had not halted the spread of knapweed. In a report in Ecology Letters, however, Dr. Pearson reports that the introduced fly has changed the ecosystem's dynamics.

The fly larvae provide an abundant food source for deer mice in the winter, above the snow. Instead of dying out, as is often the case in cold and snowy weather, the deer mice climb the stalk of the plant above the snow to the seed head. They can eat as many as 1,200 larvae a night, at a time when there is normally no other food.

Mice numbers have tripled because of this food supply, said Dr. Pearson, and with them hantavirus, a viral infection is spread by urine and droppings. It is rare, but can cause a pneumonia-like disease that can be fatal to humans.

"It illustrates the complexity of how these things play out in the system," Dr. Pearson said. "These kinds of things are not being considered" when exotics are released, he said, and there is every reason to suspect there are other, similar examples.

Since the 1970's, the importation of an exotic plant's natural enemies from its country of origin, something known as biological control, has been considered a safe and effective alternative to pesticides. Hundreds of enemy species have been released.

Biological control has worked well in some cases to tame serious problems and reduce the need for pesticides. The classic case was the release of a beetle to control a weed called St. John's wort in the 1940's.

The beetle reduced the plant to less than 1 percent of its original range, and has kept it there. To Dr. Pearson and other critics of biological control, however, the reason the process seems safe and effective is that it has not been well studied. Once an exotic is released, in other words, it isn't followed to see what happens.

"What Dean has found is the tip of the iceberg," said Svata Louda, a professor of biology at the University of Nebraska at Lincoln, referring to Dr. Pearson's study. "We don't know what we're doing when we mess up natural systems."

A major worry is that the introduced enemy will drift off target. Dr. Louda has studied the thistle flowerhead weevil that was imported from France and Italy in the 1970's to control a weed called the musk thistle, which spread across grazing land.

In Nebraska's Sand Hills, she found that the weevil switched to Platte thistle, a native plant, and, she says, has severely reduced it. She is worried the plant could disappear. Dr. Pearson's work, however, raises a new kind of problem with biocontrol — that even if an exotic species stays on its intended target, it can disrupt ecosystems and cause environmental damage.

"This is the first time anyone has shown host specific organisms can impact nontarget species," he said. "And in this case the chain goes all the way to humans." There's no research on whether human cases of hantavirus have risen because of gall flies.

"It's good science," said Jim Story, a research entomologist at Montana State University in Bozeman who has studied and introduced biological control agents for knapweed for more than 30 years. "It helps us understand the whole system. But we've never be able to eliminate all risk. I don't think this is a huge black mark against biocontrol. Any time you bring in an exotic agent you have to assume there are going to be negative effects."

Critics, he said, should focus on the damage caused by knapweed. "We're not seeing the forest for the trees," he said. "Not too many people are focused on what knapweed is doing. We have land managers screaming at our door and wanting results." Problems with the gall fly larvae may be a moot point, he says.

An exotic root weevil that has been introduced to control knapweed shows great promise. Donald Strong, a professor of biological sciences at the University of California, Irvine, has studied the ethics of biological controls and says that, while this is a serious problem, no one could have foreseen it. On balance, he said, biocontrols are critical. "Invasive species are a huge problem," Dr. Strong said. "Biological controls are a very powerful arrow in our quiver for invasive species."

In Australia, authorities have introduced a virus, originally called rabbit hemorrhagic fever, to kill the rabbits that plague the countryside. The virus seems to be working, but the release has drawn criticism and prompted fears that the disease could spread to other animals, and is not controllable.

Problems with biological controls have emerged before in the United States. In 2001, researchers found that a parasitic fly brought from Europe to control the exotic gypsy moth had switched hosts and was attacking wild giant silk moths, a large and beautiful native moth, causing a precipitous decline in population.

Both Dr. Pearson and Dr. Louda think that exotics are too liberally used. Studies show that as many as three times as many exotics have been released as there are target species. They also say there are other things that can be done to control weeds. Rather than reduce grazing, Dr. Louda contends, the agriculture officials release beetles and the rancher can go on overgrazing.

Dr. Pearson questions a fundamental assumption of biocontrol — that pest enemies of the weeds are the factor that controls them. "The natural enemies hypothesis has dominated thinking in this field for a long time," he said. "But the reasons knapweed is not abundant in Europe may be what it competes with or climate. There could be a lot of reasons."

Dr. Pearson says the gall fly has changed the deer mouse ecosystem on a large scale. Pointing to knapweed-blanketed hills on the edge of town here, Dr. Pearson said that at one time the deer mice lived in island populations, widely separated, and kept in check by winter mortality. Now those populations are contiguous. Disruptions in ecological systems are often the cause of disease.

In the East, researchers suspect, building homes in forests has pushed out predators, which has elevated populations of deer and the white-footed mouse, which are hosts for Lyme disease. Heavy rains in the Southwest last year led to a profusion of wild flowers and food for mice, and scientists predict there could be an increase in hantavirus this year as a result.

Field Trip Program

Glacier National Park

Plant Invaders-Citizen Science Field Trip

High school students on the Plant Invaders field trip in Glacier
NPS PHOTO

Description

Students will become "Citizen Scientists" and hike less than 2 miles to permanently established research plots to collect data on the percent cover of native and non-native, invasive plants. Students will return to school and add their data to the information from previous visits of other schools. They will analyze and look for patterns as the database builds each year. View our **Plant Invaders Field Trip Schedule** to see a basic outline for the day.

Glacier National Park covers an area that is a crossroads between three floristic provinces with numerous native species on the edges of their ranges. The spread of non-native, invasive plants threatens native communities and the actions of people are key to assisting in reducing their

spread.

Grade: 6 -12
Skills: Observe, communicate, identify, classify, record
Duration: 4 hours
Group Size: 45-60 total, 2 groups of 20 -30 students
Setting: First 2 miles of lower elevation trails in the park
Vocabulary: See the **bolded** words in the objectives below.

Objectives: (These are examples of some of the objectives that can be achieved on a "Plant Invaders" program. Others are possible depending on the teacher's focus and the ranger.) Students will be able to:

- Tell what national parks protect and one reason Glacier National Park was established.
- Explain why Glacier National Park is concerned about the spread of non-native, invasive plants and the loss of native plant communities.
- List 3 native plants and their uses by wildlife and people (including traditional uses by the Blackfeet, Salish, Kootenai, or Pend d-Oreille).
- Use a field guide to identify four different species of non-native, invasive plants classified by the state as "noxious weeds."
- Work cooperatively with classmates to locate and record data on the occurrences of the four targeted non-native, invasive plants along the assigned trail.
- Use a GPS to locate permanent vegetation transects to record data on non-native, invasive plants.
- Use a topographic map to correlate historic information about infestations and past treatments on non-native, invasive plants along the trail.
- Accurately complete a data sheet for recording observations of percent cover of non-native, invasive plants following the established protocols.
- Define "Citizen Science" and give one reason national parks are training people to collect data in parks and one reason many scientists don't think this is real science.
- Explain why Glacier does not ask all visitors to pull non-native, invasive plants whenever they see them.
- Input data into an Excel spreadsheet and analyze it to formulate a plan for management.
- Recognize patterns from the data collected on the trail and infer why non-native, invasive plants may be found more commonly in some areas of the park than others.
- Identify non-native, invasive plants in the local community and research local and state regulations about what is being done, and what more could be done, to control the spread of weeds.

Field Trip Logistics: Teachers wishing to have thier students participate in the "Plant Invaders" field trip should plan to arrive at Apgar by 10:00 a.m. and stay until 1:30p.m. Everyone in the group must be prepared to be outside for the entire program and be able to hike up to 4 miles over varied terrain.

Reserve a Field Trip now and check out the **Chaperone Guidelines** and our **Tips for a Successful Day** in Glacier!

Contact the park's **Education Specialist** for a CD with pre- and post-visit lessons and materials to prepare students for their Glacier field trip!

Contact

Glacier's Education Specialist

email us

406-888-5837

Details

Grade Levels:

Sixth Grade-Twelfth Grade

Subject:

Biodiversity, Biology: Plants, Botany, Conservation, Ecology, Mathematics, Science and Technology

National/State Standards:

Science Standard 1: ...design scientific investigations...

Science Standard 3: ...demonstrate knowledge of how organisms interact with each other...

type:

Field Trip Program

Last Updated: 03/28/2014

Invasive Plants Citizen Science Program

Invasive plant citizen scientists are taught how to recognize and map the presence of invasive plants in the park.

NPS

Part of Glacier's beauty includes the diversity of plant and animal life within its one million acres. Wildflower watchers enjoy the delicate painted petals of the Calypso orchid or the flashy colors of the Indian paintbrush. And almost all of us enjoy spotting mountain goats munching on alpine glacier lilies.

Glacier National Park hosts over 1,000 different types of plants, but our unique native flora has serious competition. There are currently 126 exotic plant species within the park and although many of them are not invasive, the list does include 20 noxious weeds, or highly invasive plants that are a direct threat to the proliferation of native plant communities.

The Invasive Plant Citizen Science Program assists park managers map where invasive plants exist in the backcountry. The data gathered by park staff and Citizen Scientists throughout Glacier's million acres provides critical assistance in mapping these invasive plants and managing them.

In 2008, 81 surveys were completed by Citizen Scientists of which 66 surveys involved 45 trail segments that were used in the park's invasive plant mapping database. The Exotics database is used by the Invasive Plant Biologist in determining which areas to target for treatment each year.

If you would like to learn more about the Invasive Plant Citizen Science Program, please download a copy of the education presentation as well as an example of a survey form, found below in pdf format, or view a **podcast** about the program.

Invasive Plants Citizen Science Online Training (6.3Mb)

Invasive Plant Survey Form (604Kb) *Please download prior to training*

Last Updated: 03/06/2014

LESSON 31

Virtual Survey of Invasive Plants

Grade level: 7-12
Subject Areas: Biology
Duration: 2 class periods
Setting: Classroom
Season: Any
Conceptual Framework Topics: Plant distributions, habitat, invasive species management, mapping and survey techniques

OBJECTIVES

Students will be able to understand the difference between a survey and a census, understand and implement different sampling techniques, and recognize that plants (including weeds) grow in specific niches or habitats.

METHOD

Students develop a weed sampling plan on a map of a park. They check the results of their sampling plan and calculate the area and percent of the park that is invaded by weeds.

MATERIALS

- ✎ Map of park (fictitious); attached
- ✎ Map of park (fictitious) that shows weed locations (for teacher); attached (you may want to copy this onto a plastic transparency to make it easier for students to quickly check their results with the key).

BACKGROUND

Many land managers are concerned about the spread of non-native, invasive plants (weeds) in natural areas. To be able to know whether or not weed populations are invasive, managers must first know where populations exist. Most areas are too large for conducting a census (i.e., complete count), so survey methods must be used. Surveys can tell you if and where species are present, and allow you to estimate how much of the total area is invaded. They don't tell you how many plants are present or how dense they are.

There are several such methods that can be used to survey an area for weeds. These include: (1) conducting a roadside survey, (2) surveying weeds along trails, (3) conducting surveys along transects (straight lines) that don't follow roads or trails, or (4) surveying in completely random locations. Each of these methods has potential advantages and disadvantages, and a sampling plan must consider these to get the most information possible to be able to know or predict where weeds are most likely to grow in the environment.

Contributed by Erik Lehnhoff, Center for Invasive Plant Management, Montana State University.

PROCEDURE

1. Explain to your students that they will be using a map of a fictitious area to explore how different methods of surveying an area can give different results on the distribution of invasive plants. The imaginative scenario is as follows:

- You have 4 days to sample the park area shown on the map.
- If you sample along the road, you can sample 50 squares per day.
- If you sample along a trail, you can sample 35 squares per day.
- If you sample along transects, you can sample 20 squares per day.
- If you sample with a totally random pattern, you can sample 10 squares per day.

Have students work in pairs or small groups to:

a. Choose their sampling method(s) and mark the squares on the map where they will conduct surveys.

b. Compare their map with the teacher's key to determine how many of the squares that they sampled had weeds.

c. Based on their findings, have them try to determine how much of the total area is infested with weeds.

2. When their calculations are complete, have them report to the rest of the class:

a. What method of sampling did you use?

b. How many of your sampled squares had weeds (list by species)?

c. How much of the total park area (what percent) do you predict to be infested with each weed species?

Note: Students will very likely overestimate the area infested because, without knowing it, they make the assumption that all habitat is the same. For example, if they find a certain weed in 90% of the squares they sample along a road, then they assume 90% of ALL squares have the weed. The correct way to make the determination would be to find out what percent of each habitat type has weeds, find out what percentage of the park is each habitat type, and from that, calculate how much total area has the weed species. For example, the weed may have been found in 90% of roadside squares sampled, but only in 2% of grassland squares sampled. If the park is 1% road and 99% grassland, the total percent infested could be predicted to be:
0.90 x 1% + 0.02 x 99% = 2.88% (round to 3%).

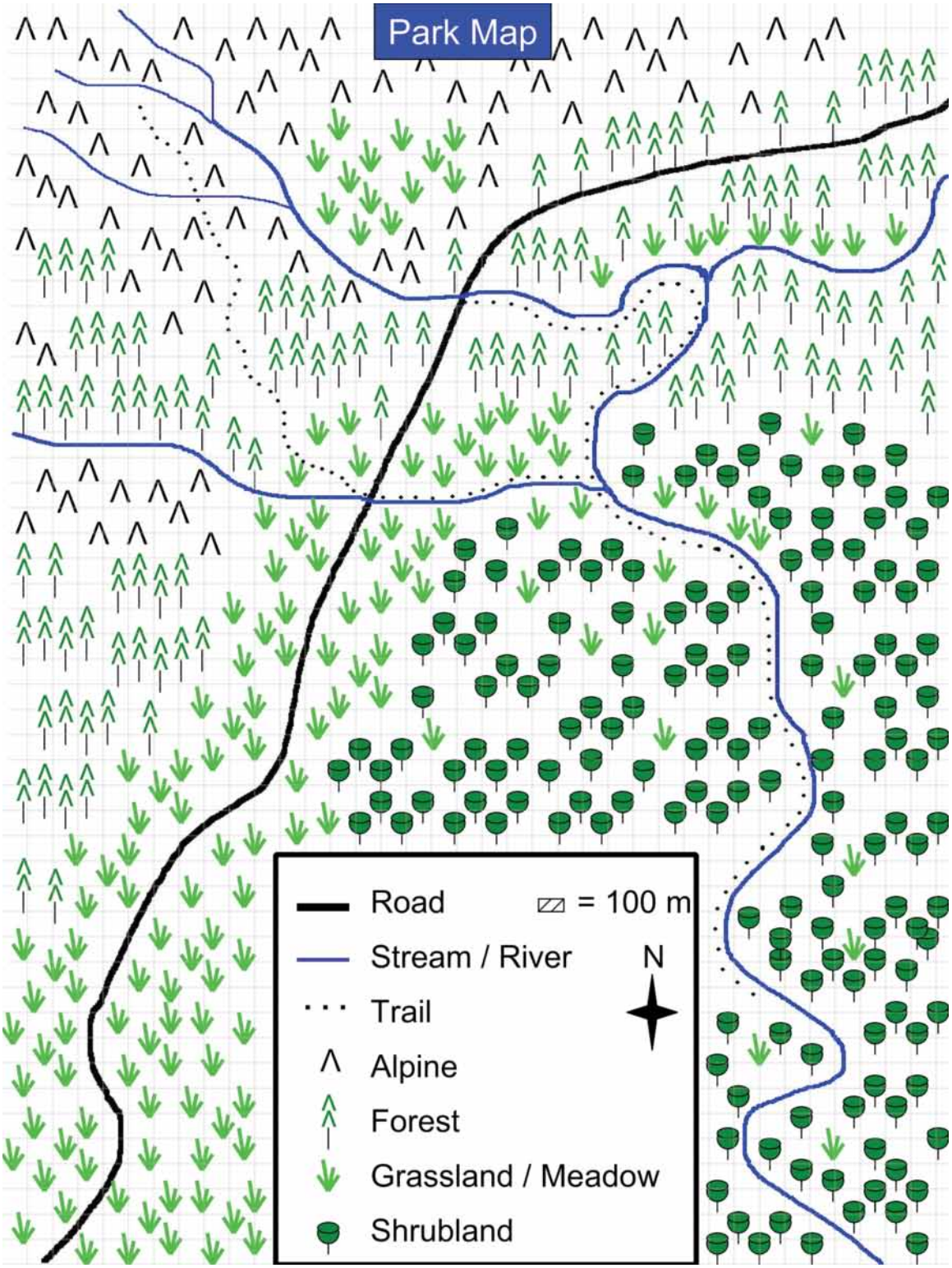
3. Discuss as a class:

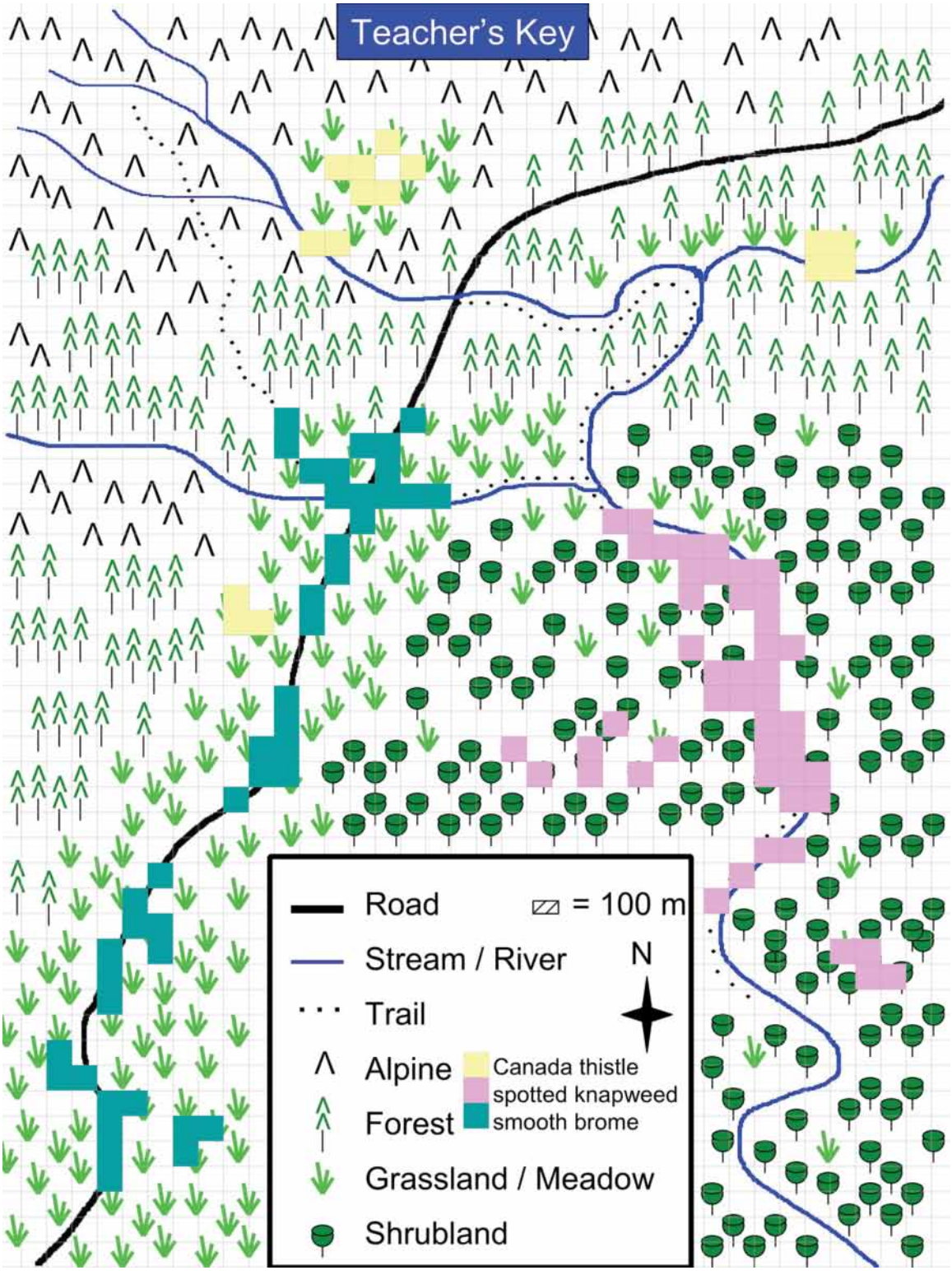
   a. How accurate were their methods?

   b. Were some methods better than others? Why?

4. If students haven't come up with the idea that they need to sample based on different habitat types, prompt them to look carefully at the maps and see if they can figure this out. Have them calculate an infestation using this method.

Extensions
Have students use their understanding of sampling methods to set up surveys for invasive plants in a park, empty lot, or another accessible area near your school.


Park Map
Road
= 100 m
Stream / River
N
Trail
Alpine
Forest
Grassland / Meadow
Shrubland


Teacher's Key
Road
= 100 m
Stream / River
N
Trail
Alpine
Canada thistle
spotted knapweed
smooth brome
Forest
Grassland / Meadow
Shrubland

Teacher's Key to habitat areas and percent infested by weeds.

Note: Many squares may have more than one habitat type. For example, all squares along the road may be considered road habitat or some other habitat such as grassland/meadow or forest. Similarly, many squares along a river could be considered to be river, trail or some other habitat. When there are multiple habitats, use the following priority: Road ➜ Trail ➜ Stream/River ➜ any other habitat.

	AREA (number of 100m x 100m squares) and percent of each habitat in park							
	Road	**Trail**	**Stream/ River**	**Alpine**	**Forest**	**Grassland/ Meadow**	**Shrubland**	**Total**
Area	99	83	177	230	315	353	387	1,644
Percent of total area	6	5	11	14	19	21	24	100

SPECIES	**AREA** (number of 100m x 100m squares) infested by weeds in each habitat							
	Road	**Trail**	**Stream/ River**	**Alpine**	**Forest**	**Grassland/ Meadow**	**Shrubland**	**Total Area Infested**
Canada thistle	0	0	4	0	0	11	0	15
spotted knapweed	0	20	4	0	0	2	22	48
smooth brome	27	8	0	0	0	9	0	44

SPECIES	**PERCENT OF HABITAT INFESTED**							
	Road	**Trail**	**Stream/ River**	**Alpine**	**Forest**	**Grassland/ Meadow**	**Shrubland**	**Total Percent of Park Infested**
Canada thistle	0	0	2	0	0	3	0	1
spotted knapweed	0	24	2	0	0	1	6	3
smooth brome	27	10	0	0	0	3	0	3

LESSON 39

Biological...*Control?:* Tweaking the Ecological Web

Grade level: 5-8
Subject Areas: Biology, language arts
Duration: One 30 to 60-minute session
Setting: Classroom
Season: Any
Conceptual Framework Topics: Ecological interactions, food webs, biological controls

OBJECTIVES

Students will understand the potential effects of biological controls on non-target species in an ecosystem.

METHOD

Students role-play different members of a Montana grassland food web, and use information collected by researchers in Montana to determine how the introduction of a biocontrol agent affects other members of the grassland community and even changes the occurrence of a deadly human disease.

MATERIALS

- **Biocontrol Cards** (at end of this lesson). You will need to make copies ahead of time; see step 1 under ***Procedure*** for the correct numbers.

BACKGROUND

Invasive species present serious threats to the biological diversity and ecological integrity of ecosystems throughout the world. Biological control ("biocontrol") is the introduction of an organism (usually an insect, fungus or bacteria) that has often evolved with the target plant species and causes deleterious effects on it through herbivory or disease. Biocontrols are promising for weed control for a number of reasons. They have been effective at reducing plant numbers in some cases, they reduce the need for other control methods such as herbicides, and they are self-perpetuating. Biocontrols must undergo thorough screening for host-specificity (that is, that they will only eat or cause direct harm to the target plant species and not other plants) to reduce the chance for their negative impacts on desirable species.

However, this type of careful screening doesn't prevent the use of biocontrols that may have significant impacts on food web interactions in the ecosystem to which they are introduced. These kinds of indirect impacts may be virtually impossible to foresee before introductions, although some general predictions can be made.

U.S. Forest Service and University of Montana researchers studying deer mice in western Montana realized that deer mice populations seemed to be much higher in spotted knapweed-infested areas than in native grasslands. They also found that deer mice were feeding heavily on the larvae of gall flies (*Urophora* species) that had been introduced in the 1970's to cause gall formation in seed heads and reduce seed production in knapweed. The gall flies have considerably reduced

the seed production in knapweed, but it has not been enough to effectively control knapweed, which continues to increase in many areas. The gall flies, however, have become as abundant as the knapweed, and are now many times more plentiful than in their native habitats in Europe.

Researchers Dean Pearson and Ray Callaway began to more closely study the interactions among these species. They found that as the gall fly larvae overwinter in the knapweed seed heads, they provide an abundant food source for Montana's native deer mice at a time when food is otherwise scarce. In fact, in areas heavily infested with knapweed, gall fly larvae make up 85% of deer mice diets in the winter. This allows deer mice populations to double and even triple in knapweed/gall fly areas in some winters, compared to the populations in native grasslands.

This change in a small mammal population may, of course, have further effects on the ecological web of the grasslands in western Montana, potentially affecting the predators and competitors of deer mice, as well as the native plants and insects they prey upon. But an additional very interesting twist to this story is that deer mice are the primary reservoirs, or carriers, of the Sin Nombre Virus, also known as Hantavirus. Hantavirus causes a deadly respiratory disease (Hantavirus Pulmonary Syndrome–HPS) in humans, with a 37% fatality rate among those who contract it (perhaps much higher if left untreated). The virus becomes airborne when disturbed, and humans catch it through exposure to mouse feces, usually in a building, since the virus is destroyed by ultraviolet light.

Pearson and Callaway also collected data on the Hantavirus occurrence in the deer mice in their study. They found that not only did the much more abundant mice in the knapweed areas carry Hantavirus, but that a greater proportion of them carried it than did the mice in the grasslands (although that difference was not great enough to be statistically significant.) So the prevalence of Hantavirus in areas with a lot of knapweed (and gall flies) is more than three times that in other areas. (Montana in 2005 was ranked as second only to New Mexico in the number of cases per capita of HPS in humans).

For more detailed information on this research, go to
http://www.rmrs.nau.edu/publications/2006_Pearson_Callaway/2006_Pearson_Callaway.pdf

For more information on Hantavirus, go to
http://www.hantavirus.net/

Your students should already be familiar with the concepts of food webs before beginning this lesson.

PROCEDURE

1. ***Ahead of time:*** Copy and cut apart enough of the **Biocontrol Cards** so that you end up with **10 bluebunch wheatgrass** and **10 spotted knapweed** cards, **6 deer mouse cards, 10 *Urophora* gall fly cards,** and **4 hantavirus (Sin Nombre virus)** cards. You might want to copy them onto stiff paper or glue them onto cardboard. You can also change the numbers of each member of the web according to the number of students you have, just keep them in roughly the same proportion.

2. To begin the lesson, if they are not familiar with the concept of biological controls, ask your students to think of different ways people might reduce or control the spread of weeds. Make a list on the board of the ideas they come up with. If they don't come up with it on their own, guide them to the idea of using natural enemies of invasive species to control or destroy them, and explain that these are called *biocontrols*. Make sure they understand the concept and ask if they can come up with some potential concerns associated with introducing one non-native species to control another.

3. Now tell your students that you are going to simulate an ecological web in the classroom, and that they are going to play the roles of different members of this web, which occurs in the grasslands of Montana. Explain that there are lots of different organisms that might be part of this web, but that you are going to concentrate on only a few members of it today. Ask them what important members of the grassland might be. When they mention grass, hand out **bluebunch wheatgrass** cards to 10 students and ask them to stand in a loose group holding their cards so everyone can see what they are. (You might want to mention that bluebunch wheatgrass is a native plant and the official State Grass of Montana.) If students come up with mice (prompt by asking them what lives in the grass), hand out **deer mouse** cards to 2 students and have them mingle with the **bluebunch wheatgrass** students. Ask if any of them know the name of a disease carried by some deer mice that can affect humans in Montana. Explain as much as you need about what Hantavirus is and how it is spread to humans. Explain that deer mice are the primary carriers, and hand out 1 **hantavirus (Sin Nombre virus)** card to a student. Have them stand next to one of the **deer mouse** card holders.

*Note: If you don't have enough students for each card, a student can hold more than one card—for example, a **deer mouse** card and a **hantavirus (Sin Nombre virus)** card. You can also change the numbers of each member of the web; just try to keep them in roughly the same proportion.

6. Tell your students that now they're going to simulate some changes in the web. Explain that spotted knapweed has invaded this grassland. Ask them what changes, if anything, they would expect to see in the web. (Have half of the students exchange their **bluebunch wheatgrass** cards for **spotted knapweed** cards, explaining that knapweed often displaces bunchgrass.)

7. Now tell your students that you are going to give them some information based on research that biologists at The University of Montana and the U.S. Forest Service conducted in the past several years in Montana. Explain that in the 1970's the gall flies were introduced to try to reduce knapweed populations, since by creating galls the flies reduce knapweed seeds in Europe, where both the flies and knapweed are native. Tell them that the flies lay their eggs in the knapweed flowers, and the larvae spend the winter in the seed head after it develops, eating plant tissue, and emerge as adults in the spring. Hand ***Urophora* Gall Fly** cards out to 5 students and have them stand next to the **spotted knapweed** students. What do they think will happen?

They will likely say the knapweed turns back to grass. Explain that while the flies do decrease seed production in knapweed, sometimes by up to 50%, it hasn't been enough to stop knapweed from spreading and becoming more abundant, since knapweed still has lots of seeds. (In some places, used in conjunction with other controls, including other biocontrols, it can help reduce the coverage of knapweed, but it is not very effective when used alone.)

Ask if they can think of any other effects the gall flies might have. Give them some time to discuss. Ask if they know what deer mice eat. Explain that deer mice are omnivorous, eating all kinds of foods such as seeds, insects, fungi, etc. They eat the gall fly larvae in the winter. Now see what they predict for their web. Explain that the researchers found that the mice were three times more abundant where there were knapweed and gall flies than in grasslands without knapweed, and ask how many mice there should be now. Hand out 4 more **deer mouse** cards.

Are there predictions for more changes? Explain that Hantavirus increases more than three times, because not only are there more mice, but since their population is denser the virus in spread among them more easily, so a greater *proportion* of the mice carry it! Hand out 3 more **hantavirus** (**Sin Nombre virus**) cards.

Questions for discussion:

1. What are the implications for using the Biocontrol gall flies to control the noxious weed knapweed in Montana?

2. Could anyone have predicted that introducing gall flies to control knapweed could have an effect on a deadly human disease?

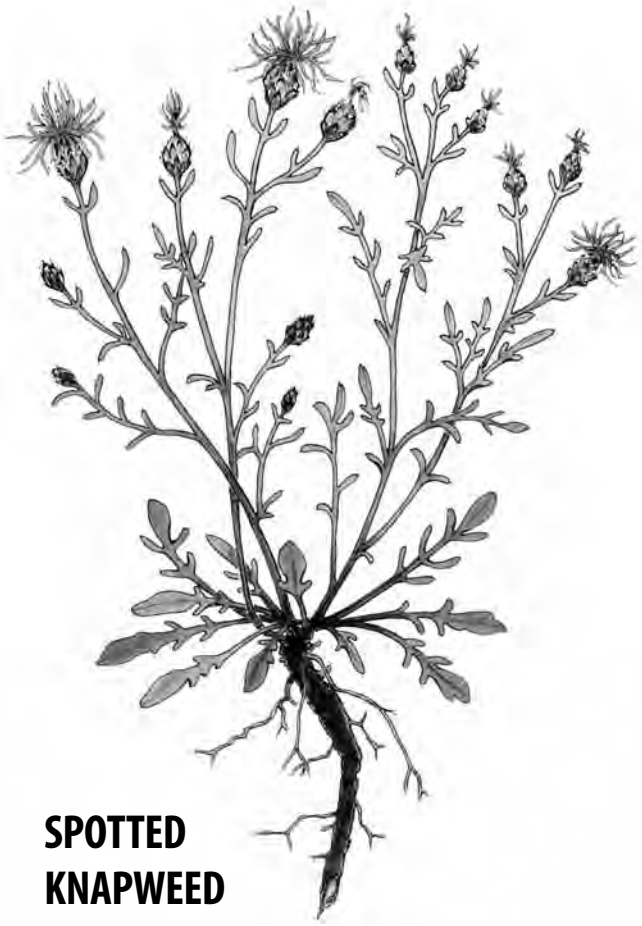
3. What other kinds of effects could these changes have? Can they imagine some other possible types of issues that might arise from introducing exotic insects or microorganisms to control invasive species?

Extensions

Have the students diagram the interactions among the members of this food web.

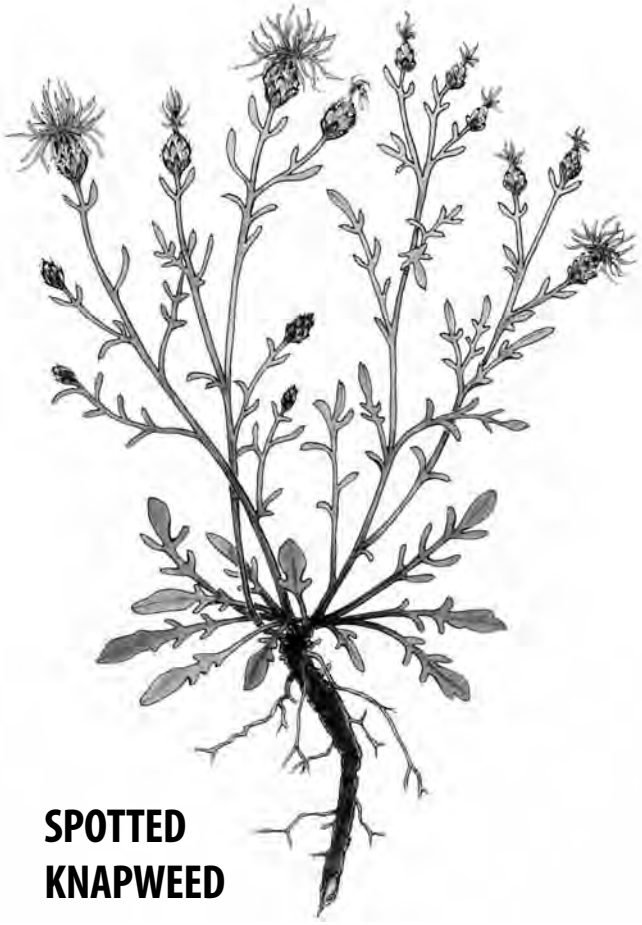
Have students hypothesize about potential effects on the ecological web of other types of biocontrols.

SPOTTED KNAPWEED



SPOTTED KNAPWEED

SPOTTED KNAPWEED



SPOTTED KNAPWEED

BLUEBUNCH WHEATGRASS

BLUEBUNCH WHEATGRASS

BLUEBUNCH WHEATGRASS

BLUEBUNCH WHEATGRASS

DEER MOUSE

DEER MOUSE

DEER MOUSE

DEER MOUSE

***urophora* GALL FLY**

***urophora* GALL FLY**

***urophora* GALL FLY**

***urophora* GALL FLY**

HANTAVIRUS (SIN NOMBRE VIRUS)

HANTAVIRUS (SIN NOMBRE VIRUS)

HANTAVIRUS (SIN NOMBRE VIRUS)

HANTAVIRUS (SIN NOMBRE VIRUS)

LESSON 40

Biological … *Control?:*
Cascading Effects of Biological Control of Knapweed

Grade level: 9-12
Subject Areas: Biology, writing, technology
Duration: One to two class periods
Setting: Classroom
Season: Any
Conceptual Framework Topics: Invasive species ecology, weed management, biological control, herbivory, human health impacts

OBJECTIVES
Students will understand the direct and indirect effects of biological controls on non-target species in an ecosystem.

METHOD
Students use cooperative learning to teach each other about the cascading effects resulting from an introduced biological control agent, involving the invasive plant knapweed, the biological control agent (gall flies), mice, and hantavirus.

MATERIALS
- ✎ **Student Biocontrol Pages**
- ✎ Article: *A Weed, a Fly, a Mouse and a Chain of Unintended Consequences* (included in lesson)

BACKGROUND
Invasive species present serious threats to the biological diversity and ecological integrity of ecosystems throughout the world. Biological control ("biocontrol") is the introduction of an organism (usually an insect, fungus or bacteria) that has evolved with the target plant species and causes deleterious effects on it through herbivory or disease. Biocontrols are promising for weed control for a number of reasons. They have been effective at reducing plant numbers in some cases, they reduce the need for other control methods such as herbicides, and they are self-perpetuating. Biocontrols must undergo thorough screening for host-specificity (that is, that they will only eat or cause direct harm to the target plant species and not other plants) to reduce the chance for their negative impacts on desirable species.

However, this type of careful screening doesn't prevent the use of biocontrols that may have significant impacts on food web interactions in the ecosystem to which they are introduced. These kinds of indirect impacts may be virtually impossible to foresee before introductions, although some general predictions can be made.

U.S. Forest Service and University of Montana researchers studying deer mice in western Montana realized that deer mice populations seemed to be much higher in spotted knapweed-infested areas than in native grasslands. They also found that deer mice were feeding heavily on the larvae of gall flies (*Urophora* species) that had been introduced in the 1970's to cause gall formation in seed heads and reduce seed production in knapweed. The gall flies have considerably reduced

(Adapted from the Ecological Society of America's *Teaching Issues and Experiments in Ecology Curriculum*)

the seed production in knapweed, but it has not been enough to effectively control knapweed, which continues to increase in many areas. The gall flies, however, have become as abundant as the knapweed, and are now many times more plentiful than in their native habitats in Europe.

Researchers Dean Pearson and Ray Callaway began to more closely study the interactions among these species. They found that as the gall fly larvae overwinter in the knapweed seed heads, they provide an abundant food source for Montana's native deer mice at a time when food is otherwise scarce. In fact, in areas heavily infested with knapweed, gall fly larvae make up 85% of deer mice diets in the winter! This allows deer mice populations to double and even triple in knapweed/gall fly areas in some winters, compared to the populations in native grasslands.

This change in a small mammal population may, of course, have further effects on the ecological web of the grasslands in western Montana, potentially affecting the predators and competitors of deer mice, as well as the native plants and insects they prey upon. But an additional very interesting twist to this story is that deer mice are the primary reservoirs, or carriers, of the Sin Nombre Virus, also known as hantavirus. Hantavirus causes a deadly respiratory disease (Hantavirus Pulmonary Syndrome – HPS) in humans, with a 37% fatality rate among those who contract it (perhaps much higher if left untreated). The virus becomes airborne when disturbed, and humans catch it through exposure to mouse feces, usually in a building, since the virus is destroyed by ultraviolet light.

Pearson and Callaway also collected data on the hantavirus occurrence in the deer mice in their study. They found that not only did the much more abundant mice in the knapweed areas carry hantavirus, but that a greater proportion of them carried it than did the mice in the grasslands (although that difference was not great enough to be statistically significant.) So the prevalence of hantavirus in areas with a lot of knapweed (and gall flies) is more than three times that in other areas. (Montana in 2005 was ranked as second only to New Mexico in the number of cases per capita of HPS in humans).

For more detailed information on this research, go to **http://www.rmrs.nau.edu/publications/2006_Pearson_Callaway/2006_Pearson_Callaway.pdf**

For more information on hantavirus, go to **http://www.hantavirus.net/**

(For information about use of the *Jigsaw* teaching method in this lesson see **http://tiee.ecoed.net/teach/teach_glossary.html.**)

In this lesson students will piece together the relationships between the invasive knapweed, gall flies, deer mice, hantavirus, and human health. The figures on the students' sheets come from three papers, each of which investigates separate aspects of the indirect effects of an introduced biological control agent.

Figure 1, from Pearson, McKelvey, and Ruggiero (2000), shows that the monthly variation in % stomach content (of deer mice) that consists of gall fly larvae corresponds with the yearly cycle of gall fly and deer mouse life cycles. (Students should realize after seeing this figure that deer mice are consuming gall flies as a large portion of their diet, and are only consuming gall flies when they exist as larvae within the seed heads of the knapweed. You may want to question students to make sure they understand this portion of the figure. For example, ask students why the dependent variable declines in June-Aug.)

Figure 2, from Pearson and Callaway (2006), illustrates that gall fly larvae density is higher in areas with higher knapweed density.

Figure 3, also from Pearson and Callaway (2006), illustrates that the abundance of deer mice, the *abundance* of seropositive (carrier of virus) mice, and the *proportion* of seropositive mice are all higher in populations containing higher densities of knapweed.

PROCEDURE

1. If necessary, explain to your students the basic concept of using biological controls as a method of managing invasive plants. Then tell them only the following about this specific case of biocontrol use: that gall flies were introduced in the 1970's to control knapweed; that gall flies lay their eggs in the flower heads of knapweed; that the developing larvae stress the plant and decrease seed production of the knapweed; and that this decrease in seed production has not been not enough to reduce the populations of the invasive knapweed.

2. Divide students into equally sized groups to form 3 total groups. Assign one group to Figure 1, one group to Figure 2, and one group to Figure 3. In a larger class, you can divide students into 6 groups (two groups to each figure). There are three different portions of the story represented by the three figures. Students are to interpret the data given in their figure and ensure that each member of their group thoroughly understands the information, as they will be required to explain it to someone who has not seen the figure yet. Give students sufficient amount of time to accomplish this. Make sure all the terms and concepts are understood (proportions as opposed to total number, life cycles resulting in changes of availability over time, etc).

Extensions

Have students create a concept map to depict the relationships between knapweed, gall flies, deer mice, hantavirus, and human health. Ask them to consider other components of the system, such as native plants, native insects, small mammals, and predators. If your students have not worked with concept maps before, briefly describe what they are, perhaps with an example.

Have your students research biocontrol agents for invasive plants in Montana.

Make sure that students read the figure legends. In particular, make sure students understand that 'seropositive' means that the mice are carriers of hantavirus. You may need to inform students that transmission rates will increase with increases in the density of the carriers. You could enforce this concept by asking students to consider the conditions under which diseases spread more rapidly (among those living in crowded cities, when people are crowded together in schools or other large buildings, etc.)

3. Then assign students to new groups, so that each member of each new group has information from a different figure. Therefore the new groups should each contain 3 members, one student having information about Figure 1, one from Figure 2, and one from Figure 3. These students are now to teach each other their "pieces" of information to "piece together the puzzle" with the goal of understanding the indirect effects of the introduced biocontrol agents.

4. As a breakdown of the figures, students should be able to conclude that (1) gall fly larvae are present in large densities in areas that contain knapweed, (2) deer mice are present in large densities in areas that contain knapweed, (3) deer mice diets primarily consist of gall fly larvae and their diets fluctuate with the life cycle of the gall fly, and (4) both the density and proportion of deer mice that carry hantavirus are higher in areas that contain knapweed. Therefore the continued presence of knapweed allows for the persistence of gall flies, which provide additional food for deer mice, carriers of hantavirus, a virus that is transmitted to humans and can be fatal.

5. After all the final groups have had a chance to share their pieces of the puzzle with one another, discuss the issue with your class as a whole. You may want to address the following:

a. Ask if the *correlations* between knapweed and gall flies, gall flies and mice, and mice and hantavirus *prove* that the biocontrol increases hantavirus occurrence. (Although the separate pieces of the puzzle suggest that more knapweed allows more flies to flourish, which allows more mice to live in knapweed areas, which in turn causes more and a greater proportion of seropositive mice, you can explain that these were *correlations*, and *causation* has not yet been supported by manipulative experiments, which would give stronger evidence. You can discuss with students how an experiment could be designed in this system.)

b. What do they think about the use of biocontrols to manage invasive species? For more discussion on this topic, have your students read and discuss the article *A Weed, a Fly, a Mouse and a Chain of Unintended Consequences*.

Student Biocontrol Page 1

Read through this page of directions and information thoroughly before examining the accompanying figure.

Individually examine **Figure 1 (graphs a and b)** and understand what the axes and data points mean. What information do the graphs provide? After everyone has completed this, discuss the figure with the other members of your group and decide what the authors wanted to convey with the data presented in the graphs. *You will need to understand the information thoroughly as you will be teaching others about it shortly!*

Share with your group any questions or difficulty you may have had with the graphs so everyone will be ready to explain them to others. Practice teaching it to each other within your group. For example, ask your fellow students: why does the dependent variable decline in June-Aug?

Figure 1 is from a paper published by University of Montana and U.S. Forest Service scientists in the scientific journal *Oecologia* in 2000. The researchers examined how much gall fly larvae make up the diets of deer mice throughout the year. The results of their study are an important piece in the ecological puzzle you will be putting together to understand the unplanned effects of an introduced biological control agent.

Gall flies (*Urophora* species) were introduced to control populations of the invasive spotted knapweed,. This species of knapweed has spread throughout the western United States and can cause many problems on rangelands and in natural areas. The biocontrol agents successfully reduced seed production of the knapweed, but not enough to effectively control populations of knapweed. However, the introduced gall flies, because knapweed still exists, continue to persist and have indirect effects on food webs and can potentially indirectly affect human health.

Now, check out your piece of the puzzle!

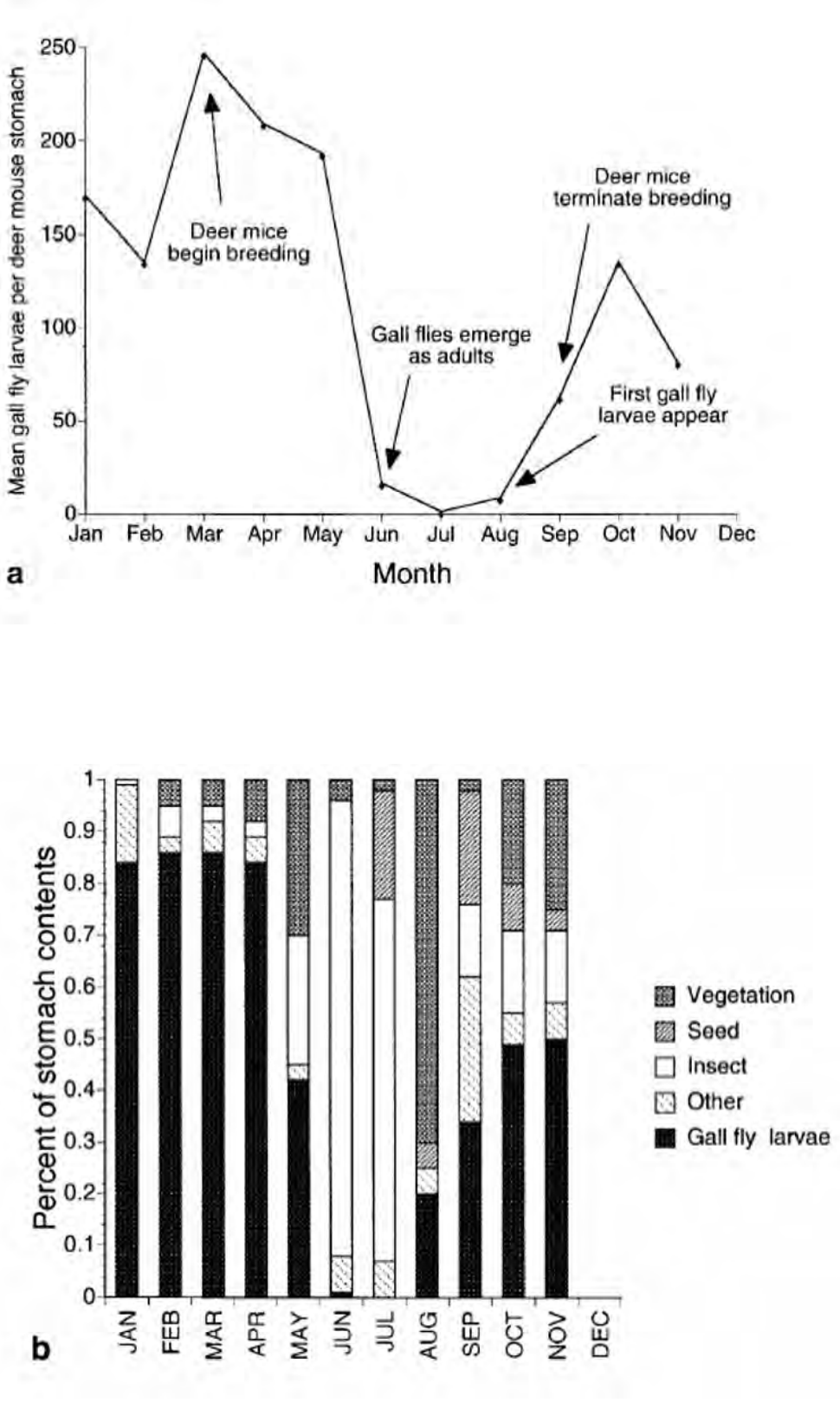


Figure 1. Stomach content analysis of deer mice from 1997-1998. Data in (a) represent mean (average) number of gall fly larvae found per deer mouse stomach each month. The arrows show different points in both the life cycle of the deer mouse and the gall fly. Data in (b) show the percent of different food items in deer mouse stomachs each month. (From Pearson, D.E., McKelvey, K.S., and L. F. Ruggiero. 2000. Non-target effects of an introduced biological control agent on deer mouse ecology. *Oecologia* 122: 121-128.)

Student Biocontrol Page 2

Read through this page of directions and information thoroughly before examining the accompanying figure.

Individually examine **Figure 2** and understand what the axes and data points mean. What information is the graph are trying to convey? After everyone has completed this, discuss the figure with the other members of your group and decide what the authors wanted to convey with the data presented in the graphs. *You will need to understand the information thoroughly as you will be teaching others about it shortly!*

Share with your group any questions or difficulty you may have had with the graphs so everyone will be ready to explain them to others. You may want to practice teaching it to each other within your group.

Figure 2 is from a paper published by University of Montana and U.S. Forest Service scientists in the scientific journal *Ecology Letters* in 2006. The researchers studied populations of knapweed (in low and high densities). One of the objectives of their study was to compare the numbers of gall flies in low densities of knapweed (where it was <2% of the vegetation) to high densities of knapweed (where it was >20% of the vegetation). They wanted to know if more knapweed means more gall flies. The results of their study are an important piece in the ecological puzzle you will be putting together to understand the unplanned effects of an introduced biological control agent.

Gall flies (*Urophora* species) were introduced to control populations of the invasive spotted knapweed, *Centaurea maculosa*. This species of knapweed has spread throughout the western United States and can cause many problems on rangelands and in natural areas. The biocontrol agents successfully reduced seed production of the knapweed, but not enough to effectively control populations of knapweed. However, the introduced gall flies, because knapweed still exists, continue to persist and have indirect effects on food webs and can potentially indirectly affect human health.

Now, check out your piece of the puzzle!

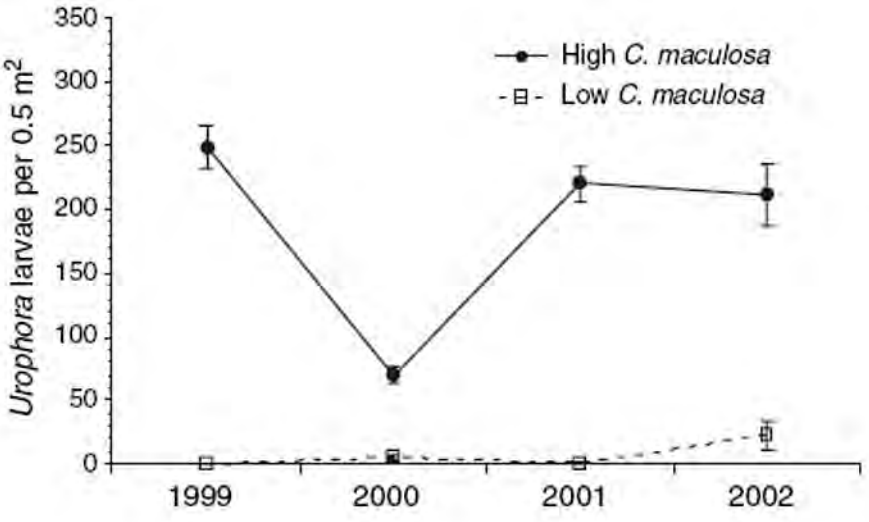


Figure 2. The mean density of gall fly larvae (+ 1 standard error) present in two populations of knapweed, one of high density (solid points) and one of low density (open points) across four years (From Pearson, D.E. and Callaway, R.M. 2006. Biological control agents elevate hantavirus by subsidizing deer mouse populations. *Ecology Letters* 9: 443-450.)

Student Biocontrol Page 3

Read through this page of directions and information thoroughly before examining the accompanying figure.

Individually examine **Figure 3** and understand what the axes and data points mean. What information is the graph are trying to convey? After everyone has completed this, discuss the figure with the other members of your group and decide what the authors wanted to convey with the data presented in the graphs. *You will need to understand the information thoroughly as you will be teaching others about it shortly!*

Share with your group any questions or difficulty you may have had with the graphs so everyone will be ready to explain them to others. You may want to practice teaching it to each other within your group.

Figure 3 is from a paper published by University of Montana and U.S. Forest Service scientists in the scientific journal *Ecology Letters* in 2006. The researchers studied populations of knapweed (in low and high densities). One of the objectives of their study was to compare the numbers of mice in low densities of knapweed (where it was <2% of the vegetation) to high densities of knapweed (where it was >20% of the vegetation). They wanted to know if more knapweed means more mice. The researchers also wanted to know if these mice were *seropositive* (which means they are carriers of Hantavirus, a potentially deadly disease in humans), how many mice were seropositive, and what proportion of the mice were seropositive in the different densities of knapweed. The results of their study are an important piece in the ecological puzzle you will be putting together to understand the unplanned effects of an introduced biological control agent.

Gall flies (*Urophora* species) were introduced to control populations of the invasive spotted knapweed, *Centaurea maculosa* This species of knapweed has spread throughout the western United States and can cause many problems on rangelands and in natural areas. The biocontrol agents successfully reduced seed production of the knapweed, but not enough to effectively control populations of knapweed. However, the introduced gall flies, because knapweed still exists, continue to persist and have indirect effects on food webs and can potentially indirectly affect human health.

Now, check out your piece of the puzzle!

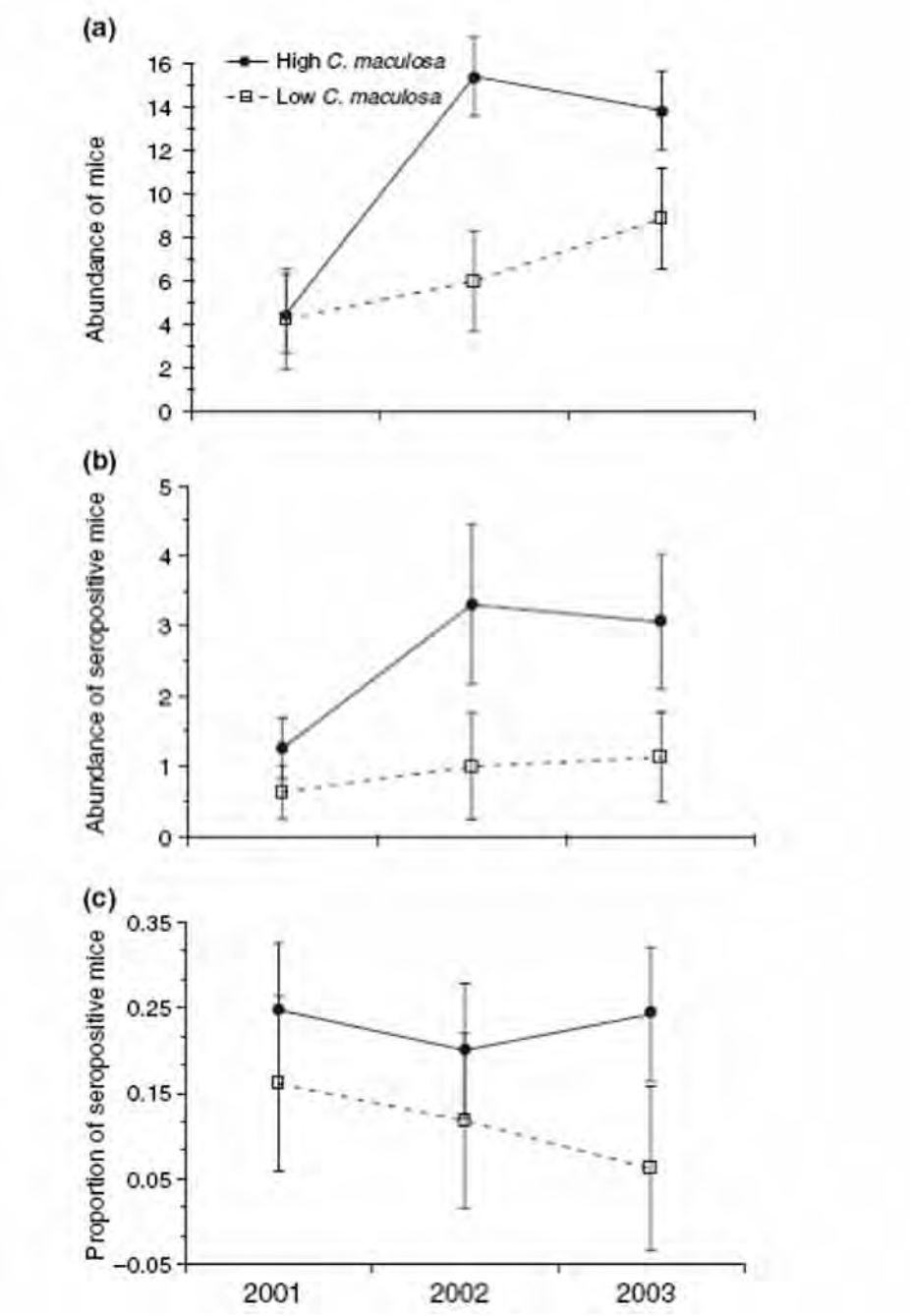


Figure 3. Data on deer mice populations in three years in areas of high knapweed density (solid circles) and low density of knapweed (open squares). (a) Abundance of deer mice. (b) Abundance of seropositive mice (mice that are carriers of hantavirus). (c) Proportion of deer mice captured that were seropositive (From Pearson, D.E. and Callaway, R.M. 2006. Biological control agents elevate hantavirus by subsidizing deer mouse populations. *Ecology Letters* 9: 443-450.)

LESSON 41

Pulling Together

Grade level: K-6
Subject Areas: Life science, language arts, visual arts, literature
Duration: 1 outdoor session and 1 indoor session
Setting: Outdoors (weedy area), Indoor (Classroom)
Season: Spring, Summer or Fall if visiting field site
Conceptual Framework Topics: Integrated weed management, weed control, monitoring, site recovery, and education

OBJECTIVES

Students will be able to describe a variety of methods that can be used for weed control. Students will be able to describe the weed control approach developed by the Bradley sisters.

METHOD

Students engage in a weed pull to help native plants return to a weed-infested area. Students also illustrate or combine photographs from their weed pull session into a series of posters or a storybook that tell the story of the *Bradley Method*.

MATERIALS

- ✎ Gloves
- ✎ String and stakes or PVC piping (optional)
- ✎ Large sheets of paper and other materials for making posters or storybooks
- ✎ Field guide to native plants
- ✎ Photos or a guide book to local noxious weeds (see ***Resources*** section of this guide)

BACKGROUND

Invasive plants populate new locations when the conditions are favorable for their survival. Left unchecked, they may replace existing desirable plant species and fill open spaces, such as disturbed sites where the soil is exposed. However, humans can help stop the spread of invasive plants. There are a number of different methods for halting the spread of invasive species. These fall into the following categories: 1. Manual (pulling, digging, cutting); 2. Mechanical (mowing, plowing, fire); 3. Biological (grazing, insects, plant diseases); 4. Cultural (prevention, educating others) and 5. Chemical (herbicides). Using a combination of methods, which is known as Integrated Weed Management, is generally more effective for weed control than any single approach.

In this lesson, students will learn about one manual approach to weed control using the *Bradley Method*, which was developed by the Bradley sisters in Sydney, Australia. Using this method, the two Bradley sisters (both over fifty) cleared a 40-acre woodland reserve so successfully that the area needed only slight attention once or twice a year (mainly in vulnerable spots such as roadsides and creek banks) to be maintained weed-free. To do this they expended only a minimum amount of time: an average of 45 minutes per day between the two of them. This low-cost, low-impact approach enables restoration to occur with minimal labor or equipment.

The *Bradley Method* can be used most successfully in natural areas where weed stands are close to or intermingled with native vegetation. This approach uses carefully planned hand weeding to tip the ecological balance in favor of the native vegetation, which is then allowed to regenerate and fill the area where the weeds have been removed. The weeding is always done outwards from the edge of the best stands of natives. The Bradley sisters recommend choosing an area you can visit easily and often, where the native vegetation meets a mixture of natives and weeds not worse than one weed to two native plants. If you choose the most heavily infested areas to clear first, the weeds will re-invade very quickly because you have provided them with ideal conditions: bare soil and full sunlight.

PROCEDURE

Gather the necessary materials including those needed for the poster or storybook activity. Find an area close to school containing noxious weeds. Select a site that primarily contains weeds that can be controlled through pulling, such as spotted knapweed. (See the ***Resources*** section of this guide to locate information on weeds and control methods that are most effective for each species.) If you or others plan to continue restoring the site using the *Bradley Method*, ideally you would select a site that has at least twice as many native plants as weed plants. *Teachers: Be sure to obtain permission from the landowner or land manager prior to conducting this activity.*

Part One: In the Classroom

Explain to students that soon we will remove weeds from a small area, but first we are going to learn about two women from Australia who used the native plants in their park to help prevent further invasion. This is the story of the Bradley sisters' method of weed removal.

The Bradley Sisters' Story

Every day the Bradley sisters would go for a walk with their dog in the park next to their home. One day they noticed that the beautiful trees and flowers that they saw since they were little girls were disappearing. Instead, they were replaced with thorny, ugly, invading weeds. The sisters decided, "These weeds have to be stopped or we will have no beautiful trees and flowers left in our park." Every day the Bradley sisters went on their walks, but this time they did something different. The sisters agreed to pull a little bit of the weeds each time they went for a walk in the park. They pulled them with their bare hands. Ouch! They only pulled the weed that grew close to beautiful native trees and flowers. They pulled them from the creeks and meadows. Slowly the beautiful native trees and flowers were able to grow and grow. Eventually they forced all the weeds away. The Bradley sisters were proud of their success. They had cleared 40 acres of weeds from the park with the help of the native plants.

They even kept a map of where they had pulled weeds and removed any weeds that tried to come into the area in order to make sure the weeds never gained ground in the area again.

Ask Students: What method of removal did the Bradley sisters use? (Manual)

Part Two: Outdoors

1. Begin by going to the selected area. Explain to students that you are going to remove invasive weeds from this area. Have students draw or take photos of what the area they treated looked like before and after treatment.

Ask students: Why would it be a good idea to remove the weeds? What are they doing to the other plants? Ask students to help identify the weeds that will be removed and verify their identification using a field guide. Point out to students that the weeds have managed to take over in this area.

2. *Ask Students:* What would be a good way to get rid of these weeds? Organize the students' answers by making a list on the paper pad. Introduce Removal Methods by categorizing their answers into the following categories:

Removal Method Categories	Examples
Manual	Pulling, Digging, Cutting
Mechanical	Mowing, Plowing, Fire
Biological	Grazing, Insects, Plant Diseases
Cultural	Prevention, Educating
Chemical	Herbicide

3. Tell the students that each of these methods may be a part of a successful plan to get rid of weeds if applied with proper planning to the right situation. Discuss with students the negative impacts of each method and ways of counteracting those negatives.

Manual: Pulling can take a long time and only covers a small area.

Mechanical: Mowing or plowing can spread seeds and destroy native plants. Fire can be dangerous to use and rarely effective at killing the live underground portions of plants.

Biological: Grazing animals (sheep, cattle) may eat native plants and disturb soil. Insects from the weed's native habitat can become pests themselves or have other unintended effects on local plants and animals.

Extensions
Have students share their posters or storybooks with other classes or in the community. Plan additional weed pull events for the selected site and engage other interested classes or groups and monitor the changes in the plant populations over time.

Have students create their own weed removal system. This can take the form of an invention or animal that could be drawn or constructed. Have students explain which removal methods are used in their invention.

Cultural: Changing our habits is not enough; we must also work to eliminate the weeds already in place.

Chemical: Some chemicals (particularly if not used properly) can harm the soil, plants, animals, and water in an ecosystem.

4. Explain to students that we are going to use the **Manual** method of removing weeds in this area, much like the Bradley sisters did in the story we heard back in the classroom. We are going to depend on everyone "pulling together" to remove these weeds. Demonstrate the correct way to pull the weeds for students, and that gloves must be worn to protect the skin from harmful substances potentially found in the weeds. Explain that if we don't pull the root of the plant it may be able to grow back quickly. Teacher Note: You may want to have students focus on one area by marking the area off with staked string or PVC pipe. This pulling activity can be made into a "Weed Olympics," with students competing to see who can make the biggest pile of weeds. Have students throw the weeds onto a tarp with a 'bull's eye' trash can set up in the middle.

5. After pulling the weeds have students help bag the weeds for proper disposal so that their seeds will not spread. Return to the classroom.

6. Ask students: Were we able to get all of the weeds in our area? (No. We cannot get all of the seeds in the ground or weeds from other areas.)

Teacher Help: Stress the importance of pulling weeds over time to slowly return the area to native plants. How can the native plants help us get rid of the weeds? (Pulling weeds can help the natives come back into the area and keep the weeds out, particularly if combined with replanting of natives.)

Why should we keep a map of where we have pulled? (We will be able to keep track of the weeds and tell others about our work to restore the native plants.)

7. Have students create a poster (or storybook) using the Bradley sisters' story from above and their own experience with the weed pull. Have students use photos or draw the important steps in the Bradley method.

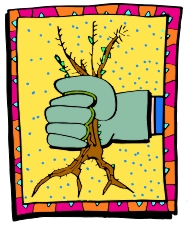
After removing weeds the group may be able to watch and maintain this area to keep it free from weeds, and/or invite other classes to join in this project.

Noxious Weed Plot Data

Plot Survey A

Directions: Count how many different types of plants you see in your hoop. Record the number in the space below. After you have looked at all the different kinds of plants, see if any of the three noxious weeds we have been studying are in your hoop. Count the total number of noxious weeds and record in the blank below. *For more of a challenge, count total numbers of each species and then add them all together for the total number of noxious weeds.*

Random Hula Hoop Toss #1



Total Number of Different Types of Plants: _____

Total Number of Noxious Weeds: _____

Extra Challenge:

Total Number of Knapweed: _____

Total Number of St. Johnswort: _____

Total Number of Oxeye Daisy: _____

Random Hula Hoop Toss #2

Total Number of Different Types of Plants: _____

Total Number of Noxious Weeds: _____

Extra Challenge:

Total Number of Knapweed: _____

Total Number of St. Johnswort: _____

Total Number of Oxeye Daisy:_____

Plot Survey B

Random Hula Hoop Toss #1

Total Number of Different Types of Plants: _____

Total Number of Noxious Weeds: _____

Extra Challenge:

Total Number of Knapweed:_____

Total Number of St. Johnswort: _____

Total Number of Oxeye Daisy:_____

Random Hula Hoop Toss #2

Total Number of Different Types of Plants: _____

Total Number of Noxious Weeds: _____

Extra Challenge:

Total Number of Knapweed:_____

Total Number of St. Johnswort:_____

Total Number of Oxeye Daisy:_____

Extension Activity: Noxious Weed Plots
(60 minutes)

Materials

- Hula Hoops
- Clip Boards
- Noxious Weed Plot Data Sheets

Procedure

1) Students will break into groups. Each group will get a hula hoop, a clipboard and a Noxious Weed Plot Data Sheet.

2) Using the "Random Hoop Toss," have students gather data on two separate survey areas. One survey area, Plot Survey A, is a human-related disturbed site and the other survey area, Plot Survey B, is a less disturbed area. *Note: these sites can be marked with string or just defined verbally.*
***For younger groups, adult chaperones are KEY to this process.**

3) Students will randomly toss their hula hoop into the survey area. The plants inside the hula hoop will be toss 1. Before the first toss, ask the group to make an educated guess, or hypothesis, of whether or not they expect to see more or less weeds in a heavily disturbed area.

4) Students will note plant diversity by recording whether they see many different types of plants (10 or more) or relatively few. They will also record weed coverage by identifying known noxious weed species in their plot and counting them. Younger students can count all weed species together for one total number. Older students should try to count totals for each know noxious weed species and then combine for overall total.

5) Students will repeat the process to obtain toss 2 data within their study site. Mention the importance of repetition in scientific data collection in order to explain to students why they are making another toss.

6) When all groups have finished recording their hoop data, ask each group to report their findings.

7) Further into the hike, students will repeat the above data collection process at Plot Survey B, a less disturbed site.

Assessment

- Upon conclusion, ask students which site seemed to have more noxious weeds. Why?

Plant Invaders—Citizen Science

Program Objectives

Grade: 6-12
Subject: Science
Skills: Observe, communicate, identify, classify, record
Duration: 4 hours
Group Size: 45-60 total, 2 groups of 20 -30 students.
Setting: First 2 miles of lower elevation trails in the park.
Vocabulary: See the **bolded** words in the objectives below.

Summary
Students will become "Citizen Scientists" and hike less than 2 miles to permanently established research plots to collect data on the percent cover of native and non-native, invasive plants. Students will return to school and enter their information into a Google Document to add their data to the information from previous visits of other schools. They will analyze and look for patterns as the database builds each year.

Objectives
(These are examples of some of the objectives that can be achieved on a forest walk. Many others are possible depending on the teacher's focus and the ranger.)

Students will be able to:

- Tell what **national parks** protect and one reason Glacier National Park was established.
- Explain why Glacier National Park is concerned about the spread of **non-native, invasive plants** and the loss of **native plant communities**.
- List 3 native plants and their uses by wildlife and people (including traditional uses by the **Blackfeet, Salish, Kootenai,** or **Pend d'Oreille**).
- Use a field guide to identify four different species of non-native, invasive plants classified by the state as "**noxious weeds.**"
- Work cooperatively with classmates to locate and record data on the occurrences of the four targeted non-native, invasive plants along the assigned trail.
- Use a **GPS** to locate permanent vegetation transects to record data on non-native, invasive plants.
- Use a **topographic map** to **correlate** historic information about infestations and past **treatments** of non-native, invasive plants along the trail.
- Accurately complete a **data sheet** for recording **observations** of **percent cover** of non-native, invasive plants following the established **protocols.**
- Define "**Citizen Science**" and give 1 reason national parks are training people to collect data in parks and 1 reason many scientists don't think this is "real" science.
- Explain why Glacier does not ask all visitors to pull non-native, invasive plants whenever they see them.
- Input data into an Excel spread sheet and analyze it to formulate a plan for management.
- **Recognize patterns** from the **data** collected on the trail and **infer** why non-native, invasive plants may be found more commonly in some areas of the park than others.
- Identify non-native, invasive plants in the local community and research local and state regulations about what is being done, and what more could be done, to control their spread.

Plant Invaders—Citizen Science (Grades 6-12)
Program Objectives continued

Montana Content and Performance Standards:
MT.SCI.K-12.1 Students, through the inquiry process, demonstrate the ability to design, conduct, evaluate, and communicate results and reasonable conclusions of scientific investigations.
MT.SCI.K-12.3 Students, through the inquiry process, demonstrate knowledge of characteristics, structures and function of living things, the process and diversity of life, and how living organisms interact with each other and their environment.

Making Connections to Glacier National Park:
Glacier National Park covers an area that is a crossroads between three floristic provinces with numerous native species on the edges of their ranges. The spread of non-native, invasive plants threatens native communities and the actions of people are key to assisting in reducing their spread.

Field Trip Logistics:
Teachers wishing to have their students participate in the "Plant Invaders" field trip should plan to arrive at the Apgar Area by 10:00 a.m. and stay until 1:30 p.m. Everyone in the group must be prepared to be outside for the entire program and able to hike up to 4 miles over varied terrain.

Plant Invaders—Citizen Science (Grades 6-12)
Typical Field Trip Schedule

Flexibility for weather conditions, bus problems, etc…is essential to having an enjoyable visit to the park. No two school programs are exactly alike, but the following schedule represents a typical trip.

8:30 a.m. – 9:30 a.m. Travel to the Park
Simple assignments can be completed by seatmates or individuals during this time. Point out sights along the way that relate to the park story such as mountain uplifting, glacially carved valleys or mountain passes, plant communities, river crossings, and canyon formations. You may also want to review vocabulary words or ecological concepts.

9:30 a.m. – 9:45 a.m. Meet park rangers at the Apgar Transit Center.
After a brief welcome by the park rangers to Glacier National Park, the ranger(s) will talk with the chaperones and teacher(s) about the schedule for the day, students will take a bathroom break.

9:45 a.m. – 10:15 p.m. Stations
Students should be in groups of 3. There will be 6 stations set up and 3-4 of the student groups will be at each station. Students will review information about non-native, invasive plants and their identification.

10:15 a.m. – 12:15 p.m. HIke
Station groups will hike with their assigned rangers/volunteers to their monitoring site and collect data on percent cover of non-native, invasive plants.

12:15 - 12:45 p.m. Lunch and clean-up
(lunch spot to be decided by ranger and teacher depending on which trail the students hike on).

12:45 – 1:30 p.m. Pull Weeds
Students pull weeds (mechanical treatment) if possible. Students must be signed up as volunteers in advance and have gloves. Ranger(s) review the educational objectives for the day.

1:30 – 1:45 p.m. Both classes meet back at the Apgar Transit Center (if others went on a different trail) and compare results. Final bathroom breaks and load up buses.

2:00 p.m. Bus leaves the park